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## Derrick Cars and Bridge Erection; Chicago, Milwaukee & St. Paul Ry.*

By J. H. PRIOR.†

The principal requirements of a derrick car are: (1) length of boom-reach, with the necessary stability of the car; (2) strength of parts, with the required lightness for handling.

The number of uses to which a derrick car can be put are almost in proportion to its length of boom. The longer the boom and the greater its capacity, the greater must be the longitudinal and lateral stability of the car. The longitudinal stability (parallel with the track) is comparatively easily obtained by increasing the length of the car and by adding the counterweight required to the weight of the engine and rigging already in place. The lateral stability is, however, a difficult matter to provide and is a more doubtful quantity than any other feature of the car; this is due mostly to the fact that the width of base of the car available against overturning is limited to the distance c. to c. of rails, unless outriggers or guys are used.

The lateral overturning moment of the load is measured by the product of the load into its distance from the nearest rail, and this overturning is resisted by a moment which is the product of the weight of the car into one-half the distance between the rails. As this half distance between the rails, or the lever-arm of lateral moment of resistance, is only about 30 ins., it is apparent that the capacity of the car for lifts at any distance from the center line of track is limited. The exact figures for the 30-ton and 50-ton cars described below are given in the accompanying table.

To reduce the stresses in the boom tackle, and its consequent weight, it is desirable to make the height of the tower as great as possible, but the permissible height of the tower is limited by the clear headroom in through truss bridges and under telegraph wires, during transit and also when the car is at work.

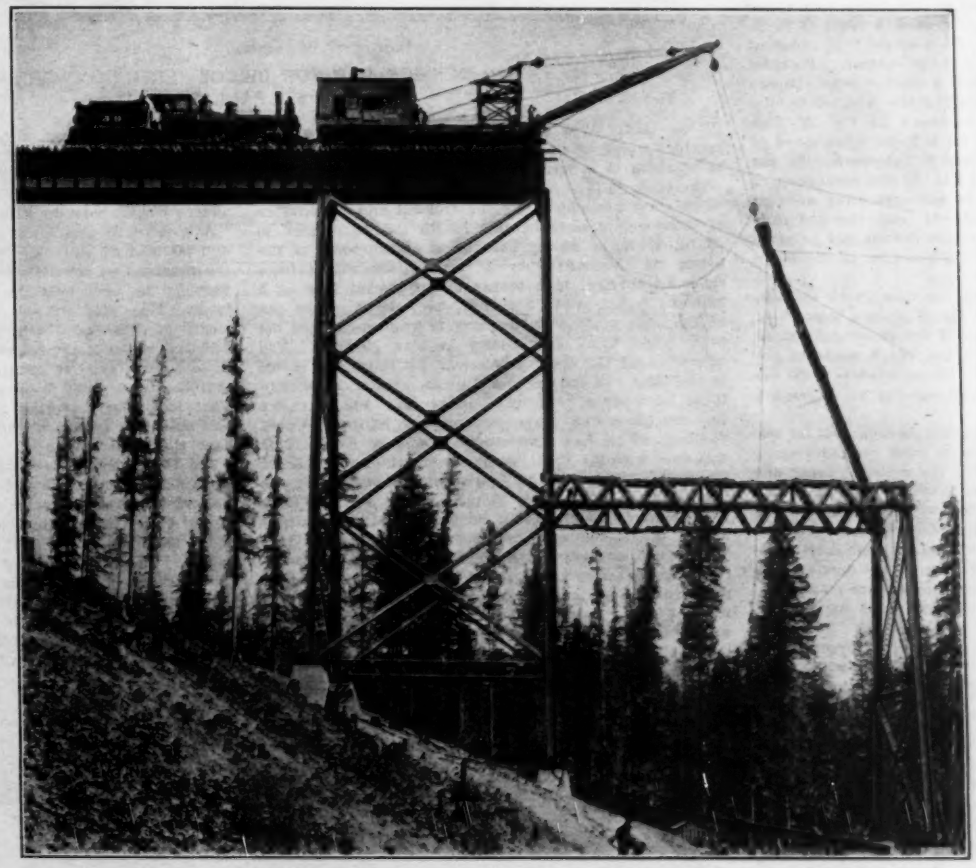

FIG. 2. ERECTION OF THE PEEDEE VIADUCT WITH 30-TON DERRICK CAR.
The Boom is Setting the Bent of a 75-ft. Span; This is Beyond Its Normal Reach, but is Effected by Outhauling, as Shown.

### 30-Ton Derrick Car.

The features of a derrick car designed by Mr. W. F. Rech for the Bridge and Building Department of the Chicago, Milwaukee & St. Paul Ry. are shown in Fig. 1. This has a 50-ft. flat car of heavy construction, carrying a mast 15 ft. 3 ins. high and a boom 30 ft. long. The top of the mast is 21 ft. 3 ins. above top of rail, and the design of the connection at the top of the tower makes practically all of this height effective.

The upper part of the tower consists of an A frame, which can be removed when the car is in transit, thus bringing the total height of the car well within the overhead clearances.

The square tower is fully rigged so that when the A frame is removed the car can be used for all purposes, but, as the stresses in the top tackle are increased, the capacity of the car is reduced.

The shortest boom is made of two 15 ft. sections; additional intermediate sections of 20 ft. and 35 ft. are provided, making lengths of boom of 30 ft., 50 ft., 65 ft., or 85 ft. available.

When heavy loads are being lifted, there is a provision for the insertion of a tight fitting hard-wood block between the body bolster of the car and the side frame of the truck. This permits part of the load to be transmitted directly from the car body bolster to the truck side frame and relieves the side bearings and springs of whatever load passes through the hard-wood block.

Fig. 1 shows the arrangement of lines, also of the clutches, brakes and throttle under the control of the engineman. These features are shown in diagram only. All winch heads and drums are provided with a ratchet and pawl.

The 30-HP. engine is of a type extensively used in bridge erection. The chief characteristic of this type (which is common to the different makes) is that all shafts, together with all gear wheels attached to same, are caused to revolve whenever steam is admitted to the cylinder. The drums run loose upon their shafts and can be made to revolve with the shafts upon which they are carried by means of friction clutches. When the friction clutch is disengaged, the drum can be held without motion by means of the brake or the ratchet and pawl, the shaft in the meantime revolving for the purpose of handling other lines.

The winch heads are also loose upon their shafts, but may be fixed to the shafts by the jaw clutches. When the jaw clutches are disengaged, the winch heads may be held in one position by means of ratchets at their ends and pawls connected to the frame of the engine. When the winch head is held against motion by the pawl, it may be used for fastening the line or holding the load, although the shaft upon which it is carried may be revolving while the engine is handling other lines.

With 110 lbs. steam pressure, the engine can exert a pull of about 8,000 lbs. on a line fastened to the drum. As this is exerted at a radius of 8 ins. from the center of the shaft, a considerable greater pull can be exerted by the winch head, which has a somewhat smaller radius.

As shown in Fig. 1, each swinging line and runner line after passing from the front of the car is given a number of wraps around the winch head and then passes into the hands of the winch head man. The pull which the winch head exerts upon the line depends upon the number of wraps which the line makes around the winch head, and also upon the pull exerted by the winch head man upon the end of the line. A very light pull, with only a few wraps around the winch head, permits the winch head to slip and revolve within the line which is wrapped around it; a greater pull and more wraps causes the winch head to grip the line with a force which can be increased up to the breaking strength of the line. The boom line and the load line are fastened to the drum, but before commencing operations, it is usual to take a few wraps around the drum, in order to reduce the stress where the line is fastened to the drum.

One engineman controls the throttle, in addition to operating the two friction drums. One winch head man operates the two swinging lines and a second winch

*Abstract of a paper read before the Western Society of Engineers and printed in full in the "Journal" of the Society.

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TABLE OF HOISTING CAPACITIES OF DERRICK CARS; C., M. & ST. P. RY.

30-Ton Derrick Car.

| Length of boom ft. | Hoisting capacity tons | Swing of end of boom from center of track ft. |
|---|---|---|
| 30 | 25 | 0 |
| 50 | 15 | 0 |
| 30 | 20 | 3¾ |
| 50 | 14 | 3¾ |
| 50 | 12½ | 5 |
| 50 | 7½ | 10 |
| 50 | 5 | 15 |

50-Ton Derrick Car.

| | | With outrigger ft. | Without outrigger ft. |
|---|---|---|---|
| 80 | 10 | 20¾ | 12 |
| 65 | 20 | 19½ | 8½ |
| 57 | 35 | 19 | 8¼ |
| 42 | 50 | 15½ | 6¾ |

head man operates the runner line when it is in use. This makes a total of three men in the cab, the engineman doing his own firing.

The car can propel itself with its own power in either direction by means of a chain wheel, which carries a 1½-in. chain; this passes around and drives a sprocket wheel keyed to the forward axle of the rear truck. The chain wheel is driven as follows:

A gear wheel is placed on each end of the front shaft, Fig. 1. The gear wheel at one end of the shaft is connected by a train of gears with the chain wheel, so as to make it revolve in the direction which the engine is running and the gear wheel at the other end of the shaft is connected by a similar train of gears so as to make the chain wheel revolve in the reverse direction. The gears at the ends of the shaft run loose and can each be thrown into service (the other gear running idle) by means of a jaw clutch, feathered to the middle of the shaft. This arrangement permits the car to be propelled in either direction by a non-reversible engine.

On a structure such as the Peedee viaduct, where the material must be brought out on the track and where falsework cannot be economically used, a boom of 80-ft. reach would be required to place a single bent ahead of the portion of the structure already erected. The same result can be accomplished with a shorter boom, though not so conveniently, by outhauling the member beyond the reach of the boom, as is shown in Fig. 2. This shows the erection of a bent for a 75-ft. span ahead of the derrick car without the use of falsework; the car sets the 75-ft. girders in position. At the conclusion of this operation the structure is self-supporting and, as soon as the laterals are placed, the track ties and rails can be laid, which will permit the derrick car to move forward 75 ft. and complete the erection of the 50-ft. tower.

The spans between towers of the Cow Creek viaduct, Fig. 3, are 61 ft. 8 ins. In order to place a tower bent ahead of the completed portion of the structure without outhauling, a boom of 66 ft. 8 ins. reach would be required. These bents, however, were placed with the 65-ft. boom available, the small amount of outhauling being done with hand lines.

The material for this viaduct was brought out to the point where it was required by a track on the ground along the center line of viaduct, the material being delivered to the tramway from the track above by a wrecking crane, which happened to be available. This method differs from that used at the Peedee viaduct (Fig. 2), where all material was delivered above and carried to its position suspended from the boom of the derrick car. This method of bringing out the material was made possible by the level bottom of the valley which the viaduct crosses.

Fig. 2 shows also the lower story of the tower being erected by a mule traveler, running on a wide gage track and moving continuously away from the portion of the structure erected. This arrangement, which kept the derrick car continuously supplied with material without moving from its position at the end of the completed portion, greatly increased the erection speed. This viaduct (consisting of 27 spans supported by 12 towers) was erected by the company forces in 18 consecutive days.

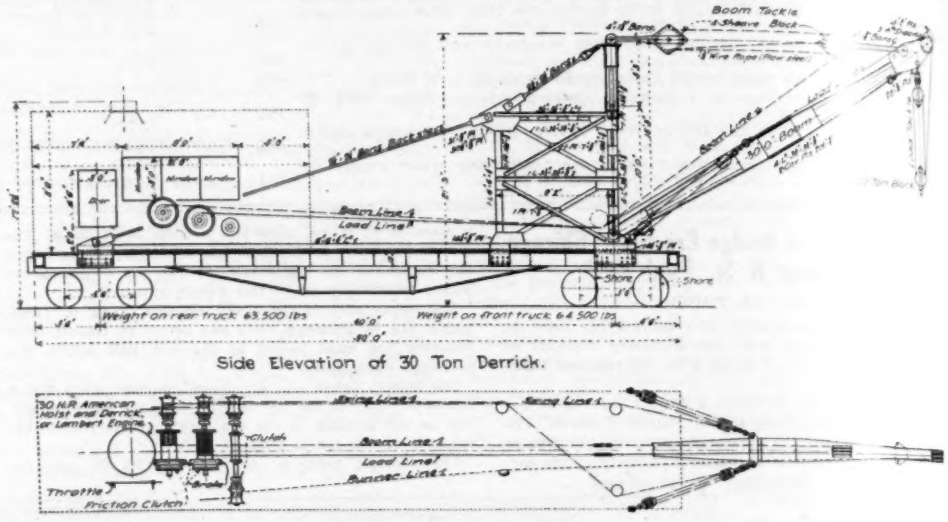
### 50-Ton Derrick Car.

The general features of the 50-ton derrick car designed by Mr. W. E. Pruett are shown in Fig. 4. The principal requirements of design and the difficulties encountered in satisfying them (as given in the description of the 30-ton car) are equally true as applied to the 50-ton car. But in this case the essentials of reach, stability, etc., were provided in a somewhat different manner. The longitudinal stability of the car was increased by the addition of 25 tons of counterweight; and its lateral stability by the use of outriggers.

The machine consists of a steel superstructure mounted on a steel flat car. The A-frame, which performs the work of a mast, is riveted to two transverse channels which are fitted to two circular castings resting on the plates riveted to the sides of the car. The channels form a box, into which the I-beam outrigger telescopes when not in use, and from which it can be withdrawn, when required, to either side of the car, depending upon the point from which the load is to be lifted. The outer end of the outrigger rests on blocking or a jack bearing against the ground.

To reduce the stress in the boom tackle, the A-frame is made as high as possible, being 21 ft. ¾ in. over all above the top of rail. This height is within available clear headroom, but can be materially reduced by revolving the A-frame backwards around the casting (as shown in dotted lines) when the car is in transit.

At the top of the A-frame is a forging revolving on its horizontal axis and having bearings for its ends in the A-frame and backstays. A vertical pin passes through this forging. To this vertical pin are attached two short eye-bars, which are also attached to the lower block of




Side Elevation of 30 Ton Derrick.

Diagram of Lines.

FIG. 1. 30-TON DERRICK CAR FOR BRIDGE ERECTION; CHICAGO, MILWAUKEE & ST. PAUL RY.

the top tackle. The backstays are also connected to this forging, which is about as central a connection as can be obtained in a derrick car.

The boom is in sections and has a maximum length of 80 ft. when assembled. By the removal and substitution of intermediate sections, this length can be reduced to 65 ft., 57 ft. or 42 ft. The thrust of the boom at the bottom is transmitted by a casting terminating in a spherical surface, to a bronze bushed socket forming a ball and socket joint. The 16-ft. bars shown at the end of the boom tackle are necessary to keep it clear of the boom when using long booms at high elevation. The capacities of the boom in various positions are shown in the table. In spite of instructions, greater loads than these have often been lifted in service. Fig. 5 shows the car placing a tower bent of the Blacktail Creek viaduct, which has intermediate spans of 65 ft. This was done with the 80-ft. boom, the length of which made it possible to do all this work without outhauling, as in Fig. 2.

The engine and propelling device are of the same type as on the 30-ton car, but the engine is of 50 HP. There is a locomotive air-compressor on the car, with two storage tanks under the floor. With 110-lb. boiler pressure this will supply sufficient air at 100 lbs. pressure for the operation of five riveting hammers. The compressor also furnishes air for the air brakes, and the brake equipment has proved a valuable safeguard when moving the car towards the end of a structure under erection, often on a falling grade.

The two cars described have been employed for over a year, often for duties beyond their rated capacities, and have given satisfaction to the field forces of the Bridge Department.

### Traveler for Viaducts.

Where it was necessary to erect a viaduct on a new line before the track had reached that part, and where the erection of high structures had to be hurried to completion before an approaching winter in a country noted for heavy snow falls, it was necessary to design an erection machine with a capacity for the continuous and economical employment of a larger working force than would be possible with the der cars, the increase in working force to result in pr tional increase in tonnage erected per day. Such a e is the travelor designed by Mr. H. C. Lotholz, a wn in Fig. 6. This is a combination structure of wo d iron, which spans the track, thereby permittin terial to be brought to the traveler on flat cars a as (B), and also permitting the passage of trains gh the traveler immediately after completion of tructure.

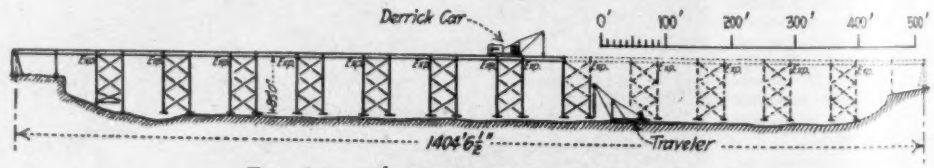
This traveler has a cantilever arm -ft. and two 60-ft. wooden booms, making a total r of about 120 ft. This reach makes it possible to t an entire tower in advance of the completed por of the structure (as shown in Fig. 7), the tower g stable in itself without the use of temporary braces. The cantilever arm is equipped with four trolleys, each of 15 tons capacity. Each trolley is composed of a steel carriage on rollers, from which are suspended two four-sheave blocks, rove up with nine parts of 1½-in. rope.

A hook of 10 tons capacity was hung from each boom and 30 tons of rails for counterweight were placed at the rear end of the traveler. Additional anchorage was provided by anchoring the traveler to the girder with hooks. The traveler was also anchored sideways by means of three ⅝-in. hoisting cable guys, on each side, attached to top of the traveler. The machinery is of the same general type as for the 30-ton derrick car, except that the front shaft is omitted and the power is somewhat less. The following description of the equipment and operation applies to one side only, but both sides have the same equipment.

The 10-ton hook at the end of the boom is suspended from a four-part tackle of ⅝-in. hoisting cable. The fall line of this leads through the idler sheave at the top of the boom, thence through a snatch block at the foot of the mast and thence to the lower drum of the hoisting engine. The boom is raised or lowered by a seven-part tackle of ⅝-in. cable, the fall line of which leads through a snatch block at the foot of the mast and thence to the upper drum of the engine. The hook hoist and boom hoist are operated by the engineman.

The boom is swung laterally by a five-part tackle (one on each side) of 1½-in. manila rope. The fall line of this is led through a series of snatch blocks (which prevents the lines from fouling other parts of the traveler) to the outside winch head on hoisting engine. Both of these lines are operated by one winch head man.

Each of the 15-ton trolley hooks is supported by a nine-part tackle of 1½-in. manila rope. The fall line passes through a snatch block of two idlers at the forward end of the cantilever arm, and thence back through a number of deck sheaves (which keep the lines from fouling other parts) to the inside winch head of the engine. As there are two trolleys, one fall line leads to each inside winch head on the engine. This fall line is used also for traversing the trolley, there being sufficient tension in the fall line, when holding the load,




Tower Spans, 40' Intermediate Spans, 61'to 61'8"

FIG. 3. ERECTION OF THE COW CREEK VIADUCT BY A GROUND OR MULE TRAVELER FOR THE LOWER PORTION AND A DERRICK CAR FOR THE UPPER PORTION.

to move the trolley forward, the trolley being also under the control of the trolley tail line. One winch head man is required to operate each trolley tail line.

The trolley tail line leads from its fastening to the trolley, through two snatch blocks to a cavel on the deck of the traveler. In order to keep the trolley under control when it is being hauled forward by means of its own fall line, the tail line which is snubbed around the cavel is paid out at the required speed from the cavel. When the trolley is being hauled towards the rear of the traveler for another load, the trolley fall line and the trolley tail line are interchanged, the former being wrapped around the winch head to haul the trolley back, and the latter being snubbed around the cavel and paid out at the required speed. Each trolley tail line requires the entire attention of one man.

There are also two runner lines, each of which passes from the load to a snatch block fastened to a stump and leads from this block over the end of the traveler to the outside winch head of the engine, on which they are operated simultaneously with the swinging line. These lines are operated by one of the regular men on the traveler.

Six men have been enumerated in handling the lines, twelve men being required for both sides. Two of these men are available usually for handling signals, as they are not continuously engaged with their lines. A third signal man, with the assistance mentioned above, transmits all signals. This gives a total of 13 men on top of the traveler; 37 additional men were required to fill the crew for this work.

Fig. 7 shows all lines in operation, in the erection of the 105-ft. tower of Clear Creek viaduct. The two booms are placing two columns with boom tackles No. 1 and No. 2; trolleys No. 3 and No. 4 are simultaneously placing two other columns for the same tower. Runner lines No. 1 and No. 2 are in service ready to outhaul these columns to their exact location. Trolleys No. 1 and No. 2 are lowering to the ground two loads of sway bracing, which will afterwards be picked up and placed in position by the runner lines No. 1 and No. 2, at present running to the stump and being used for outhauling. This illustration also shows a carload of columns which has been run part way through the traveler, which will be lifted from the car by the trolleys and lowered to the ground.

As shown, the traveler is employed to its maximum capacity and working 50 men. The viaduct, which is 210 ft. from base of rail to ground, partly on a 10° curve, was erected in 28 working days, by the forces of the Bridge and Building Department under the direction of Mr. F. J. Herlihy.

Fig. 7 shows also the Tekoa viaduct, on a new line, which was erected before the tracks reached its location. The material for this viaduct was delivered to the foot of an inclined tramway (25% grade), on which it was hauled up the hillside by means of hoisting engine and cable rove into a six-part tackle. Fig. 8 is a view of the erection of this viaduct by the traveler.

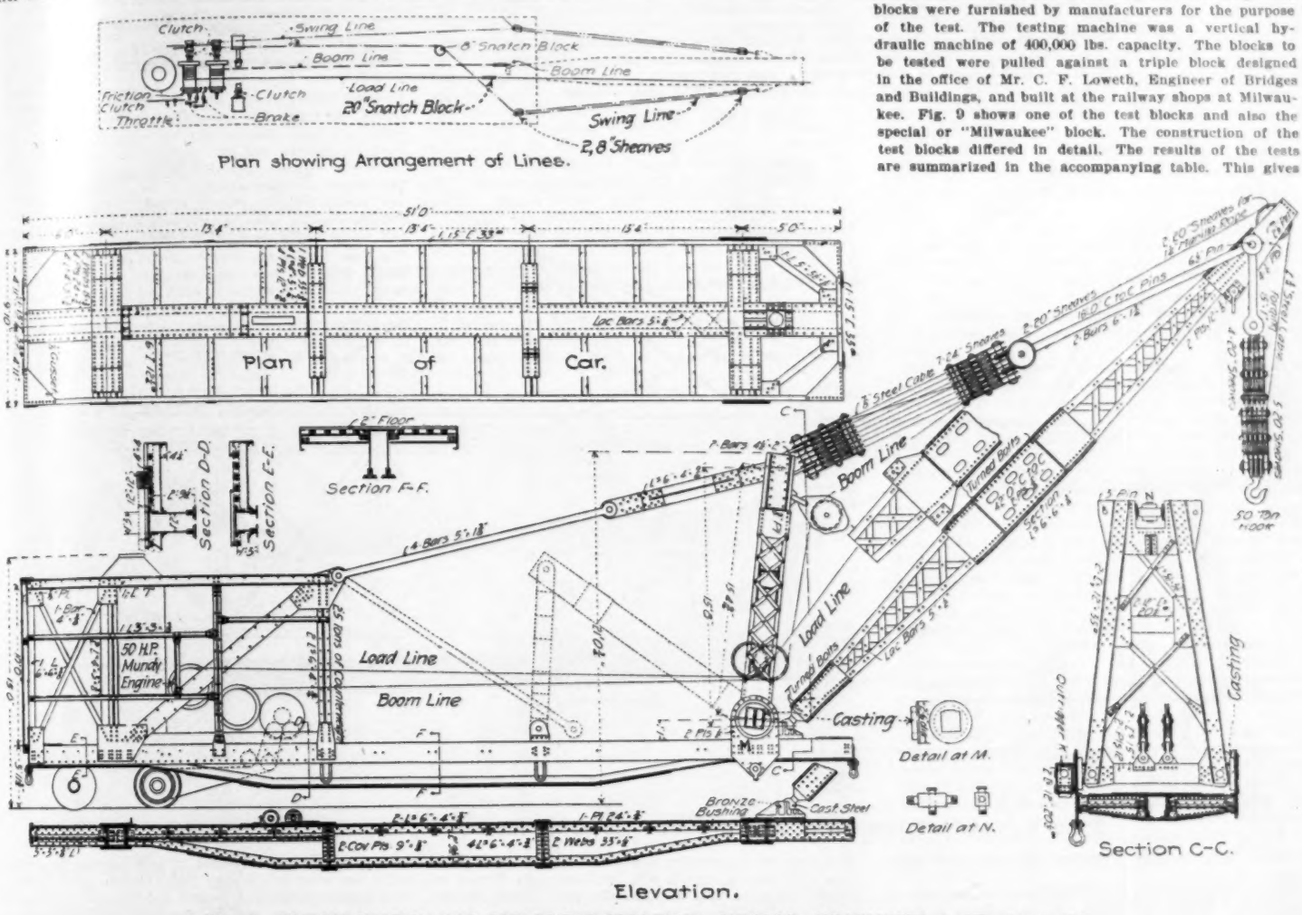



FIG. 4. 50-TON DERRICK CAR FOR BRIDGE ERECTION; CHICAGO, MILWAUKEE & ST. PAUL RY.

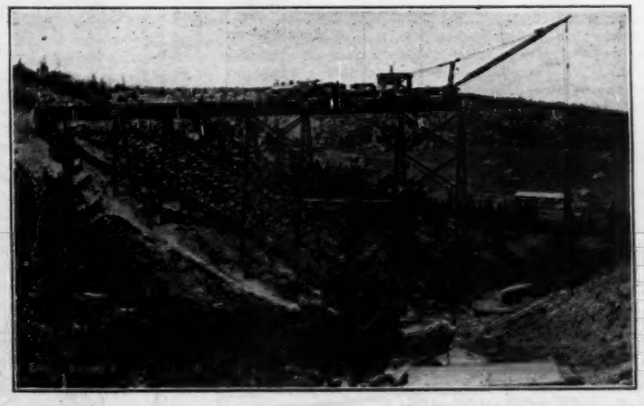


FIG. 5. ERECTION OF THE BLACKTAIL CREEK VIADUCT (65 FT. SPANS) BY A 50-TON DERRICK CAR WITH 80-FT. BOOM.

### Tests of Iron Pulley Blocks.

Tests of triple-sheave blocks as used for tackle of this kind were made at the testing laboratory of the University of Wisconsin in 1908 by M. C. Withey. The blocks were furnished by manufacturers for the purpose of the test. The testing machine was a vertical hydraulic machine of 400,000 lbs. capacity. The blocks to be tested were pulled against a triple block designed in the office of Mr. C. F. Loweth, Engineer of Bridges and Buildings, and built at the railway shops at Milwaukee. Fig. 9 shows one of the test blocks and also the special or "Milwaukee" block. The construction of the test blocks differed in detail. The results of the tests are summarized in the accompanying table. This gives also the weights of the blocks. Part of the weight of the Milwaukee block was due to the use of 21-in. sheaves (instead of 13½ ins. to 16 ins. in the test blocks) to reduce the bending stress in the rope.

| Block. | Weight lbs. | Breaking load lbs. |
|---|---|---|
| 1 | 277 | 148,000 |
| 2 | 275 | 151,000 |
| 3 | 225 | 86,500 |
| 4 (Fig. 8) | 358 | 255,000 |
| 5 (Fig. 9) | 350 | 258,000 |
| "Milwaukee" | 720 | Not broken |

Both blocks were rove together with ⅞-in. hoisting cable, the ends of the cable being fastened to the tail bolts of the upper and lower blocks respectively, by means of three clips at each tail bolt. The tension heads of the machine consisted of clevises with pins of large diameter; these pins passed through the clevises of the blocks to be tested. The load was applied gradually and continued until a cracking sound was heard or some indication of failure was seen or suspected. Then the load was released and the block was carefully examined for signs of failure. After several repetitions, the load was continued until the failure was complete. The "Milwaukee" block was in the upper head of the machine and in all cases the lower block failed, while the upper block remained practically intact.

Fig. 9 shows block No. 5, and Fig. 10 shows a view of block No. 5 after failure. The details of the tests of these two blocks are given below. [We omit the detailed description of test and failure of other blocks.—Ed.]:

Test of Block No. 4.—At 150,000 lbs., load was released; no sign of failure. At 170,000 lbs., load released; clearance observed below tail bolt; clevis scaling on inside; clevis pin bending. At 188,000 lbs., load released; clevis scaling all over; inside and outside straps scaling; inside strap moved down at least ⅛ in., mark seen at top of strap. At 208,000 lbs., load released; clevis pin easily seen to be bent. At 247,000 lbs., cotter sheared off on clevis pin on one side; head pin bending up. At 255,000 lbs., cotter on sheave pin sheared off on

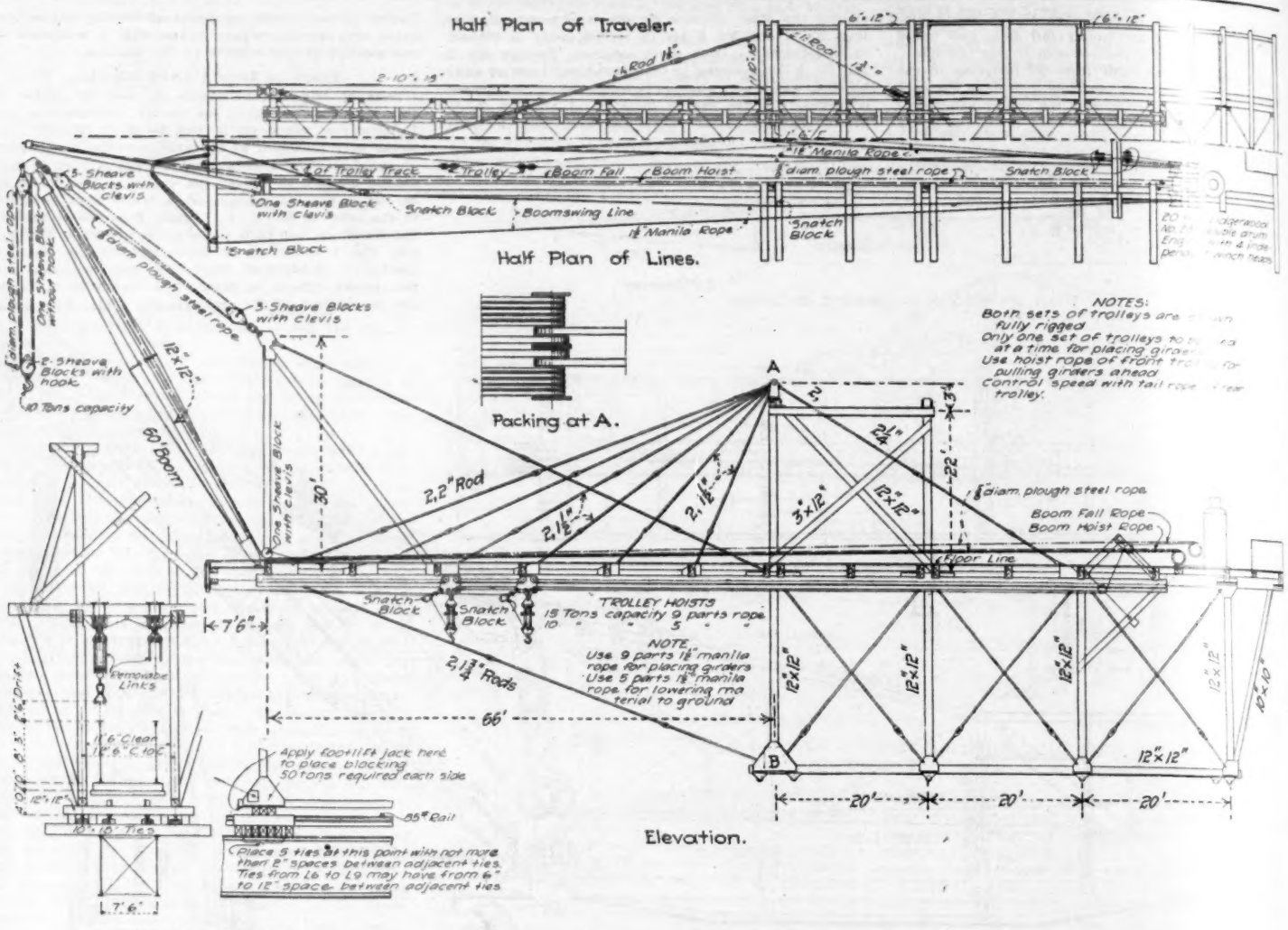

Half Plan of Traveler.
Half Plan of Lines.
Packing at A.
Elevation.
Blocking at B.
NOTES:
Both sets of trolleys are shown fully rigged
Only one set of trolleys to be used at a time for placing girders
Use hoist rope of front trolley for pulling girders ahead
Control speed with tail rope of rear trolley.
5-Sheave Blocks with clevis
2-Sheave Blocks with hook
10 Tons capacity
60' Boom
One Sheave Block with clevis
Snatch Block
Boomswing Line
Boom Fall
Boom Hoist
1¼" Manila Rope
¾" diam. plough steel rope
Snatch Block
2,2" Rod
2,1½" Rods
2,1¾" Rods
30'
66'
7'6"
TROLLEY HOISTS
15 Tons capacity 9 parts rope
10 " " 5 " "
NOTE
Use 9 parts 1¼" manila rope for placing girders
Use 5 parts 1¼" manila rope for lowering material to ground
Apply footlift jack here to place blocking
50 tons required each side
85# Rail
Place 9 ties at this point with not more than 8" spaces between adjacent ties. Ties from L6 to L9 may have from 6" to 12" space between adjacent ties
Removable Links
12"×12" Ties
12"×12"
3"×12"
24"
22'
Floor Line
20'
20'
20'
10"×10"

FIG. 6. TRAVELER FOR BRIDGE AND VIADUCT ERECTION; CHICAGO, MILWAUKEE & ST. PAUL RY.

one side, load dropped to 229,000 lbs. and block failed with loud report.

Test of Block No. 5.—(1) The block was pulled to 196,000 lbs., when the rigging in the testing machine broke. End of cable was fastened to outside segment of tail bolt. Tail bolt was bent in block where cable was attached. No other sign of failure noticed. (2) With cable undisturbed from first test, block was pulled again. At 235,000 lbs., clevis pin began to bend, causing block to skew upward on side where tail bolt bent. Pin hole in plates at clevis much elongated. At 255,000 lbs., ¾-in. tail bolt sheared off with a loud report. As only the tail bolt had failed where the cable was attached, it was thought advisable to put in a larger tail bolt and test the block to complete destruction.

(3) A 1-in. wrought-iron bolt was substituted, the holes being drilled larger in block. The end of cable was fastened at center segment of tail bolt. Load of 158,000 lbs. was applied and released; tail bolt was observed to be slightly bent. Maximum load applied was 258,000 lbs., after which load was released and block examined. Sheave pin badly bent, cotter broken off; both inside shell plates split; tail bolt bent upward; both inside shell bolts had moved upward ¼-in., due to bolts and sheave pin bending. Load was reapplied to get complete destruction. At 255,000 lbs. inside shell plates had raised ¾-in. and load began going back until about 178,000 lbs.; at this load block burst apart with a loud report. Just previously the inside shell plates had raised 1⅛ ins.

CANADA'S PORTLAND CEMENT PRODUCTION in 1908 was 3½ million barrels, an increase of a million over 1907. About 800,000 bbls. of this remained unsold, however. The average price at works was $1.39, against $1.55 in 1907. About half a million barrels was imported into Canada during the year. The production was from 23 plants, six more than were operating in 1907. However, this list includes one natural cement plant (listed as making "natural Portland cement"). One of the plants making artificial cement uses blast-furnace slag. The increasing production in Canada has reduced the imports very rapidly; five years ago more cement was imported into Canada than was made there, but since 1906 the ratio has been decreasing rapidly, until now the imports are only about 15% of the production. The import duty is 43¾ cts. per barrel (levied on gross weight, at 12½ cts. per 100 lbs.).—From figures given in a bulletin of the Department of Mines, by I. McLeish, Chief of Division of Mineral Resources and Statistics, Ottawa.

A TRAIN-FERRY between India and Ceylon has been authorized by the government of India. The South Indian Ry. has a line terminating at Pamban, on the straits, and opposite this is a series of reefs and channels known as Adams Bridge. Several projects have been proposed for a viaduct at this crossing, somewhat after the plan of the line from Florida to Key West. The present authorized project includes the extension of the railway across the Pamban Channel to Daneshkodi Island. On the Ceylon side, a railway will be built from Manar Island to the mainland of Ceylon and some point on the Ceylon Government Railways. The distance between the two islands, about 40 miles, will be served by the train ferry. This arrangement will avoid only one transfer, as the South Indian Ry. has a gage of 3 ft. 3⅜ ins., while the Ceylon Rys. have a gage of 5 ft. 6 ins., so rolling stock cannot interchange.

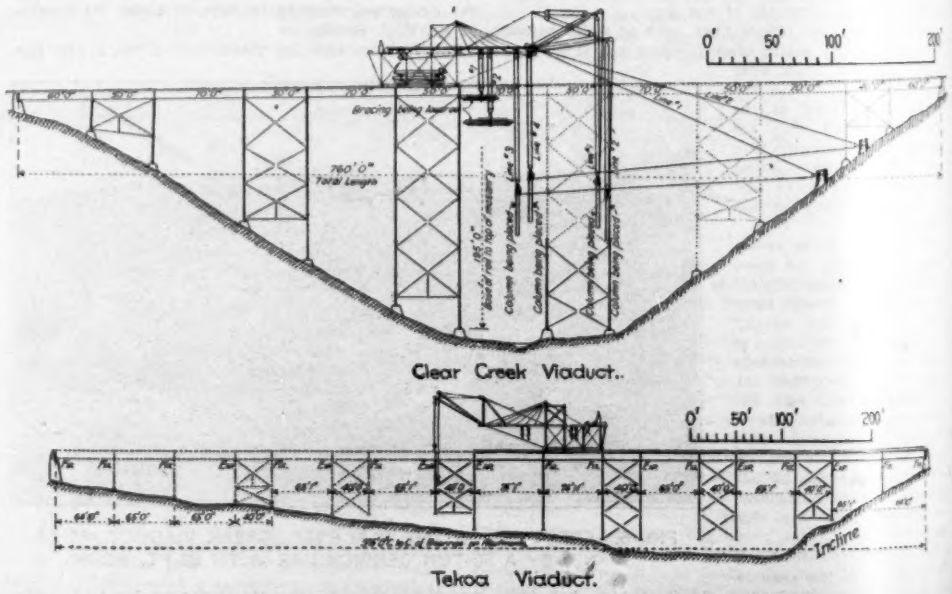



FIG. 7. METHOD OF ERECTION OF VIADUCTS BY TRAVELER.

Joints No. 3 and No. 4 are simultaneously

of an inclined tramway (25% grade), on which it was

up. At 253,000 lbs., cotter on sheave pin sheared off on



## Education for Utility and Culture.*

By DR. CALVIN M. WOODWARD.†

The early universities came into being as a part of the grand revival of learning which prevailed in Italy, Germany, France and England in the 14th and 15th centuries. They were the joint product of Protestantism and the art of printing. The former declared it the privilege of all to read the New Testament and the Fathers in the original Greek and Latin. The art of printing laid open to all the world all the treasures of ancient learning.

Oxford and Cambridge came into notice about the year 1300, and for some four centuries they were the recipients of repeated gifts and benefactions from the rulers and the nobility of England. As the universities grew the course of study slowly expanded. In the beginning they were largely Latin grammar schools for monks and priests. Even in Queen Elizabeth's time, Oxford was little more than a Divinity School. Undergraduates were 14 or 15 years of age and often younger. The "Trivium" leading to the degree of Bachelor of Arts consisted of Latin grammar, logic and rhetoric. There was no Greek until the time of Erasmus in 1511. Even a Latin version of Aristotle's Logic was used.

Having completed three years in the study and practice of dialectics, the student became a Bachelor of Arts and "incepted" or "commenced" the four years of

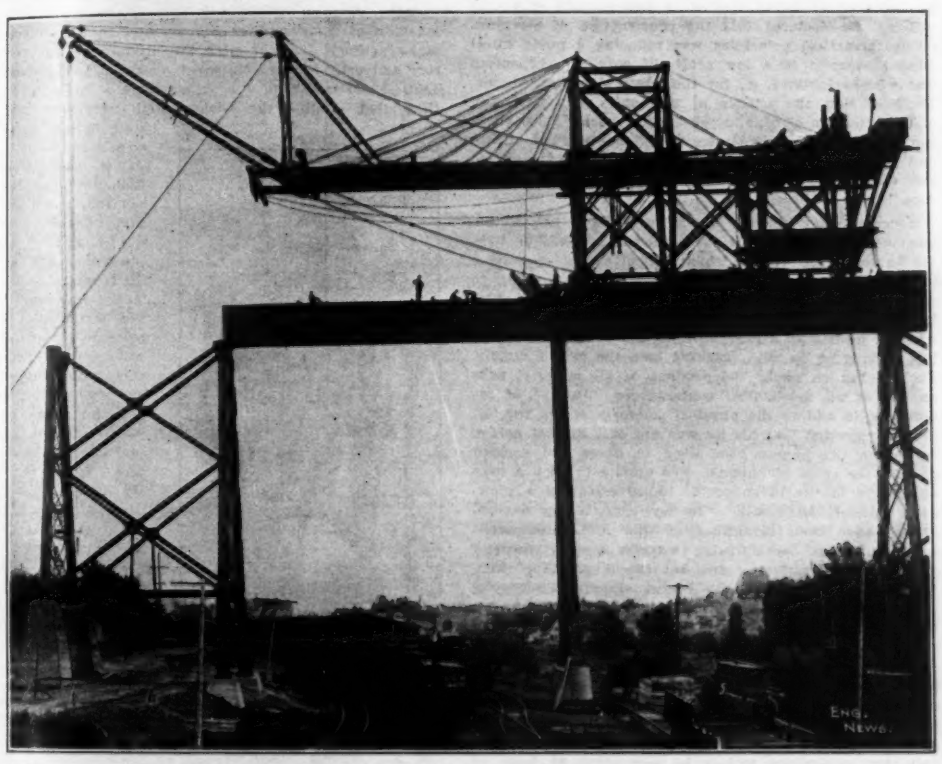


FIG. 8. ERECTION OF THE TEKOA VIADUCT BY A TRAVELER HAVING A 75-FT. CANTILEVER WITH TWO 60-FT. BOOMS (VIADUCT SPANS 70 FT.).

study of the "Quadrivium" which led to the degree of Master of Arts. The ceremony of Commencement took place naturally at the beginning of the fourth year, when the student received his first degree and entered upon the higher courses of study. The Master's degree was conferred at the end of the seventh year. You will observe that we have retained the name "Commencement" to mark the termination of the first course, and not at all to signify the beginning of the Master's course; and that the ceremony is held at the beginning of the summer vacation instead of at its end, as formerly.

The Quadrivium included: 1, arithmetic or the science of numbers (there was for 300 years afterward no algebra, no trigonometry, no analytic geometry, no calculus); 2, geometry, i. e., Euclid and maps, which included all the geography which was known; 3, music; 4, astronomy, as taught by Ptolemy.

No poets or orators were studied at Cambridge till the early part of the 16th century. Their introduction was due to Erasmus, who came to St. John's College in 1511. During the Chancellorship of Thomas Cromwell in the reign of Henry VIII., it was ordered that undergraduates should be instructed in logic, rhetoric, arithmetic, geography, music and Aristotle.

In 1549 the trivium was changed to mathematics, dialectics and philosophy; the quadrivium to more philosophy, perspective drawing, astronomy and Greek.

Such was the course of study that for centuries constituted the education of the youth of England who were destined to fill places in the church, to become barristers, physicians, or gentlemen of leisure. For such and such only was education supposed to be necessary.

In his famous Tractate of Education, written 24 years after the landing of the Pilgrims on Plymouth Rock, Milton wrote only for the rich and for those of noble birth. He advised the study of the poets, orators, historians and philosophers of Greece and Rome. There was little else to study. There was no science, for the speculations of Aristotle in regard to physics and the constitution of matter were unworthy of the name of science, though they blocked all scientific progress for over a thousand years. English literature did not exist. Modern mathematics is the product of the last 200 years. Milton himself followed in the track of Virgil, as Virgil had followed in the track of Homer. "Paradise Lost" was modeled after the Aeneid, and "Lycidas" closely resembles one of the "Bucolics" of Virgil.

Milton wrote and sang for the few. The great bulk of the English people, the farmers, the sailors, the miners, the tradesmen, the manufacturers, the builders of houses and shops, had no education and were supposed to need none. Popular, universal education, as we understand the term, is less than 40 years old in England. During all these years, while England was growing great, Cambridge and Oxford continued to build on the lines I have described. They had a monopoly of the education of the English ruling and property classes. No men trained differently were brought into competition with these men. Hence the claim, often made, that the greatness of England's great men is due to the fact that their training was classical rather than scientific is extremely illogical.

No one denies great intellectual value to ancient as well as to modern classics, but we have learned that men may be educated in more than one way; that the old road is a long road, a comparatively dull and uninteresting road; a road blocked up by dead issues, ancient ruins, over the graves of extinct nations, and through an atmosphere redolent with the air of antiquated myths. The classical period was a civilization of art and luxurious culture based on conquest and human slavery.

Such was the old university, and such in many institutions is the ideal to-day. But all such ideals must be classed with the ancients. It is their glory to be old, as though age in itself were a virtue.

I visited an endowed school in Manchester, England, a few years ago. It was hundreds of years old. It had its ancient halls, its ancient studies, its impassable fence, and its locked gate. But gradually its style of household furniture had become transformed. A modern kitchen, a new dinner service, carpets and chairs reminded one of modern life.

Then the craze for antiquity swept over the Board of Management and they decided to put the school back 200 years to the actual style of living in "the good old times." Out went the carpets, the cooking stove, the dining table; off went the table cloth and modern spoons and forks; modern chairs, napkins and plates. The pupils adopted again the ancient dress; they cooked on spits and behind tin ovens over open fires in huge fireplaces; they sat on benches without backs, at a rough oak table above a stone floor; and ate from pewter plates and drank from pewter mugs. Grace was said in Latin before and after meat. I assure you it seemed to me like a grand burlesque for the presentation of which a hundred little boys were being trained to act their parts.

In striking contrast with all this mockery of antiquity was a modern manual training room with the best of modern tools and appliances. This latter was the gift of an enthusiastic friend who thus redeemed and modernized the entire school.

Up to 60 years ago, the honors at Cambridge were awarded only in classics and mathematics. In 1848 two new "triposes," or honors, were established, viz., in Moral Science and in Natural Science. Then came the Law Tripos, the Historical Tripos, the Theological Tripos, the Semitic Language Tripos, the Indian Language Tripos, and finally, the Modern Language Tripos in 1886.

During the last few years, Mechanical and Electrical Engineering have gained a foothold in Cambridge and recently they have been placed on a permanent footing. A manual training shop has even secured recognition among the "modern side" people of Cambridge.

Higher education in the United States started on a somewhat different plan and it has had a very different development. When Harvard College was started, 200 years ago, it was a feeble imitation of one of the colleges of Cambridge University in England where John Harvard had been a student; but there was in every New England village a school where the rudiments of an education were accessible to all. In those days Harvard College was what would now be called a classical high school. It was pre-eminently a school for the preliminary training of clergymen and lawyers. It was Latin, Greek, mathematics, logic, rhetoric and metaphysics from first to last. The course of study had not changed in character very much when I was a student there 50 years ago, but a wonderful transformation has taken place since then.

The study of materials, the study of the laws of construction, the distribution of forces, the analysis and limits of internal stress, the transformation and utilization of energy; the study and use of exact methods and instruments of precision; the elements of drafting, shopwork, and the essential features of prime movers—all these studies have made this progress possible, and they promise yet greater progress, if the proper education is furnished.

We are at last beginning to understand that the education which is to be universal should be a very different thing from the education of a privileged few. The new education which dominates the modern colleges and universities aims to train men to high efficiency along all lines, practical and theoretical, as well as artistic and spiritual. The old procrustean bed on which all were stretched or trained to the same course of study has been banished, never to return. The characteristic features of the new university are freedom of choice and a thoroughly practical treatment of the chosen branches.

A university is a place where one should be able to study the best that has been said and done in the world. In our secondary schools one may acquire the rudiments of an education, may learn how to study, may become somewhat familiar with the breadth and scope of the object of study; but in the university he should directly attack the masterpieces of thought and achievement; should dip into the choicest and most invigorating springs and drink deeply.

From the days of John Milton, in 1608, to the end of the 18th century, university training culminated in a preparation for the professions of law, medicine and theology, and in the training of the nobility for the duties and responsibilities of government and elegant society.

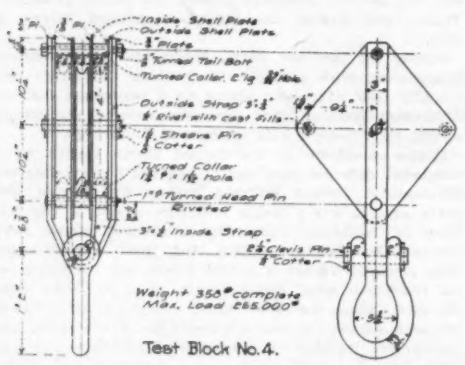
But when alchemy developed into chemistry; when physics became an experimental science; when Leibnitz and Newton elaborated the infinitesimal calculus; when Watts invented an efficient steam engine; when Fulton built a successful steamboat; when Stephenson devised the locomotive and constructed a road with smooth rails; and finally when Siemens and Gramme produced the electric motor—vast fields of fascinating and useful material were opened for study and research. Mathematical analysis and the principles of mechanics, which had previously been devoted to the problems of physical astronomy, were now directed to the study of the transformation and transmission of energy, the theory of structures, and the phenomena of electricity. The theory of evolution has given a new meaning to all vital phenomena; and the doctrine of the conservation of energy has permeated all our study of motion and force.

*An address before the graduating class of the Missouri School of Mines, at Rolla, Mo., June 8.

†Dean of Washington University Engineering Schools, St. Louis, Mo.

In the earlier days Alexander Pope voiced the popular notion that "the proper study of mankind is man." "Nature Study," which to-day is the bright attractive feature of the primary school, and equally the inspiring field of the savant, was not countenanced by polite society. For centuries it was held to be little short of blasphemy to wound the earth by digging for ores which were intended to be hidden away from our sight and touch; or to attempt in any way to improve upon God's workmanship. When in 1680 a Spanish engineer proposed to deepen the channels of certain rivers and to restrain their overflows in the interest of navigation, the Spanish Council decreed as follows: "If it has pleased God that those rivers should have been navigable, He would not have needed human assistance to make them so; but as He has not done it, it is plain that He does not want it done"; and the improvements were forbidden.

It has taken many centuries for the world to discover that the great forces of nature are neither sacred nor profane, neither kind nor cruel, that they neither love nor hate, and that they are more unchangeable than the stars; that shrines and temples, priests and priestesses, tripods and oracles have been in vain except so far as they reacted upon the human heart and satisfied

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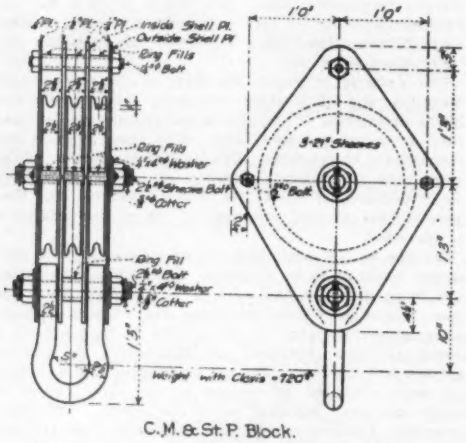



C.M. & St. P. Block.

Fig. 9. Pulley Blocks for Derrick Cars.

its natural craving for the worship of a Superior Being. Instead of building a temple to the far-darting Apollo or to Zeus the Thunderer, we now stretch over our cities a net-work for artificial lighting; and all the winds that blow and all the waters that flow are made to furnish their tribute to our comfort and pleasure. We tap the sources of endless energy and transmit it through all the ramifications of our social order, relieving mankind from heavy burdens and creating hundreds of occupations hitherto all unknown.

Out of all this vast extension of the horizon of human activities, and this multiplication of occupations, has come an imperative demand for technically educated men. In our industrial system the crying want has been and is for men who can both plan and execute. The secret of our recent success in foreign markets lies in the fact that we have put educated brains into our products and into our methods of manufacture. Hence a score of professions unthought of 100 years ago have been called into being, and the standards of these new professions are intellectually not one whit lower or less humane than the old.

Our best preparation for the future is a mastery of what has already been achieved. Our undergraduate period should be devoted to the study and mastery of established truths and accomplished facts, as embodied in language, literature, and the achievements in the arts and sciences. As Matthew Arnold put it: "The student should study the best that has been said and done in the world." I like Arnold's statement exceedingly, if I can only make it broad enough to include the wonderful results of applied science during the last hundred years. I am one of those who believe in progress, in the superiority of our own age. I regard the conquests over matter and force through intellectual processes of the highest order, as among the best things that have been done in the world, and I include what has been discovered and well established in the realm of natural history and applied art, as well as in the realm of ethnology and sociology. The world has been slow to accept the dignity of a scholarship for service. The old idea of culture was not that which enables one to accomplish something for others, but that which was valued for what it was supposed to accomplish for one's self—as Emerson puts it.

It is interesting to note how strong and enduring has been the prejudice against any scholarship that was suspected of being useful. Among the Greeks and Romans of the classic period, it was held to be not only undignified but ignoble to personally provide food, clothing and shelter for one's self or for one's family. The educated man must not build his home, nor even plan it. He must neither cultivate crops nor cook his food; neither manufacture cloth, nor make garments. All such work was for slaves, white, black or yellow.

It was the business or occupation of the gentleman (who alone received any education), to manage his family (including his slaves), fight for his country whether for conquest or for defense, cultivate art, poetry, athletics, mathematics and logic. Even Plato considered geometry as degraded by being applied to any purpose of vulgar utility. He declared that the construction of machines on mathematical principles was reducing a noble intellectual exercise to a low craft, fit only for carpenters and wheelwrights; i. e., for the white slaves of Athens. He held that the science of mechanics was unworthy of the attention of a philosopher. For nearly 2,000 years the brightest minds of Greece and Rome scorned utility, and they discouraged all studies which aimed "to add to the comfort or alleviate the calamities of the human race."

Macaulay says (in his Essay on Bacon) that Seneca was indignant because Democritus was praised for having invented the arches which supported the roof of a temple. He maintained that philosophy has nothing to do with teaching men to rear arched roofs over their heads. The true philosopher, he said, does not care whether he has an arched roof, or any roof. Philosophy has nothing to do with teaching men the use of metals. She teaches us to be independent of all material substance, of all mechanical contrivances. Instead of attempting to add to the physical comforts of his species, Seneca regretted that his lot was not cast in that golden age when the human race lived in caves and dressed only in the skins of animals. To impute to such a man any share in the invention or improvement of a plow, or a mill, is an insult. "In my time," says Seneca, "there have been inventions of this sort, transparent windows, tubes for diffusing warmth equally through all parts of a building, etc., but the invention of such things is drudgery for the lowest slaves. Philosophy lies deeper. It is not her office to teach men how to use their hands."

Bacon sets out deliberately to overthrow the influence of Greek philosophy as regards usefulness, and with unequaled force and skill proclaimed the dignity and nobility of useful studies, and of service to humanity. I feel sure that the spirit of service through the discovery and presentation of scientific truth lives and thrives, and that nevermore will it be necessary, at least in America, for a man of science to apologize to the world for making his discoveries and inventions useful to mankind.

We have been told that engineering studies and pursuits make men sordid and narrow. The statement is not true. It is true that such studies make one feel the weight of coming responsibilities, as well as the absolute necessity of mastering fundamental principles. Engineering students rarely feel at liberty to burn their old text-books. They have been thought to be somewhat lacking in reverence, and unpoetical. I must confess they are generally not given to the worship of the ancients, but they are not without poetic instincts.

Do not for one moment suppose that all knowledge is contained in books, or that all art is to be found in museums, or that all poetry is written with pens. To a mind filled with a sympathy that is born of intimate knowledge, there is in a mighty moving mechanism, and in the proportions and grandeur of a great superstructure that obeys all the laws of science, a beauty that delights the eye; a harmony and bond of thought, a rythm and rhyme of reason that falls upon the inward ear like heavenly music.

The problems of engineering are not all solved. In fact the work of solution has but just begun. There is plenty for you to do as you step from the lecture room and laboratory to take up the responsibilities of educated, well-trained men. The best thought of to-day is that the wealth of nature is not to be squandered and wasted. Our natural resources are to be conserved. We are to be not only husbandmen, but thrifty husbandmen.

Is there any doubt about the worth of your product? The price of wisdom is above rubies. Solomon prayed for a "wise and understanding heart" and his prayer was granted. A wise and understanding heart means more than scholarship, more than mere technical skill, more than technical acumen, more than mere popularity. It may include all these, more than several of them—it must include high character, an unspotted life, a devotion to what is true in form and in essence, a consecration to service:

. . . "I pray thee then—
Write me as one who serves his fellowmen."

I wish you personal success in a very high sense, and to that end I wish to impress upon you two things. I do not mean that you should study your work, go to the bottom of every problem you have to meet. You will do that anyway, if you are made of brain and material capable of intense stress and a high elastic limit. The two things I emphasize are these:

(1) An inflexible determination never to indorse what you believe to be bad engineering. Let the temptation be ever so great, the bribe ever so fascinating, stand like a rock. Let the wind blow, let the rain descend! stand your ground! Some years ago I wrote in an album as a "Maxim for Conduct":

"In matters of sentiment, go with the stream; in matters of principle stand like a rock." Carry that away with you.

(2) Cultivate the graces and refinements of really good society. Acquire (unless you have it already) a perfect mastery of your mother tongue, and in leisure hours make yourself familiar with the masterpieces of literature and art. For ten or twelve years the late Professor John B. Johnson and I were members of a Fortnightly Club that studied the books which were well worth studying and discussing, from Homer to James Russell Lowell. Professor Johnson felt, and I feel, that those hours were full of the greatest profit and the keenest pleasure. Your influence in the world and the pleasure of your life will depend partly upon your engineering skill, but more upon your manners, your speech and your breadth of culture. Too often in the past the engineer has been associated in the popular mind with a smoky chimney, greasy machinery, and bad English. Accordingly a recent writer in urging a more generous course of study for technical students, says: "It will be a sorry epitaph, that one was born a man, and died an engineer." Let your epitaph be: "Here lies one who was born a common man and who died a great engineer."

Fig. 10. Failure of a Pulley Block Tested to Destruction in a Testing Machine.

One word more. You are to be not only engineers and cultivated men—you are to be citizens. As already hinted, you are to serve your fellowmen. You are to combine Utility and Culture in Service.

We live in a new world, under the light of a new civilization. Our institutions are not founded or buttressed by human slavery, white or black; might no longer makes right; the burly robber of the Middle Ages is no longer our ideal of a good citizen. We are as certain of the Brotherhood of man as of the Fatherhood of God.

Bloody war is being relegated to the past; our ideas of heroism and manly nobility are not to be found in the prize ring or in the arena; they are to be found in the performance of the many duties of citizenship. Fellowship and not warfare should be our motto. Cooperation rather than hostile competition should be our practice. It is a glorious thing to help solve problems in such a way that every solution leads on to a higher civilization. Let us tear down the walls which separate nations one from the other, let us dismantle the forts, disband the army, and let us among ourselves lay aside warfare and adopt the methods of brotherhood. It is yours to help on the happy age when Science and

"art shall flourish,
And knowledge shall grow to more and more,
And all men shall be brothers,
And the most useful shall be the most beautiful,
And "Service" shall be the watchword,
The key that shall unlock the gates of Paradise."

# A Suggestion of a Type of Lock for the New Government Canal at Sault Ste. Marie Including a Criticism of the Present Poe Lock.

By GEORGE A. BURLEY.*

It is not the author's intention to belittle the Poe lock at the Sault as compared with other existing locks; but, inasmuch as the Poe is the highest type of lock construction extant, to show certain defects in its construction and operation, and to suggest a type of lock that will overcome them. The same criticism, and more, will, of course, apply to locks of construction inferior to that of the Poe.

The distinction above accorded to the Poe is justified by the fact that several foreign countries have sent their engineers to inspect its design and workings, and have adopted many of its details. The United States Government will adopt many of its features in the great canal now being constructed at Panama. Measured by its dimensions and by the tonnage it accommodates, also, it is by far the most important canal lock at present in operation in the world.

The total number of vessels passing through the Poe lock in the year 1907 (from April 23 to Dec. 11) was 8,475, which includes everything from large freighters to small launches. The average time of lockage for these vessels was 2 hours and 40 minutes, which includes passing through the 1⅞ miles of canal. The average time consumed in lockage alone, per vessel, was 35 minutes and 9 seconds.

For those who are unfamiliar with the construction and working of the Poe lock, a brief description of the same will be given, in order that such remarks made herein as are applicable to it may be understood.

In Fig. 2, a rough outline of the Poe lock is shown. The chamber is 800 ft. between the upper and lower service gates, and 100 ft. wide. It is filled through a series of openings, of uniform size, in the floor, leading from 8 × 10-ft. culverts underneath. These culverts, six in number, pass under the upper service gates and receive their water-supply from above them. Four culverts extend to within about 100 ft. of the lower service gates, and the other two only half way down the chamber.

Emptying is accomplished through an area-way cut across the lock floor immediately below the lower ends of the long filling culverts, from which six short emptying culverts lead out under the lower service gates. Each set of culverts has a combined cross-section of 480 sq. ft., and the depth, including the bed sills and lock floor, is about 15 ft. It follows that this method of filling through the false floor necessitates excavation for a depth of 15 ft. below the bottom of the lock chamber.

The gates, and the manner of their operation, are roughly shown in Fig. 2. The gates, AB, are hung on the vertical axes, A, and meet when closed at B. They are opened by cables from B to C. The power used to operate the gates is hydraulic, and, not being applied tangent to the arc described by the point B, it follows that some of the power is lost in operation.

To open the gates, it will be seen that it is necessary to move all the water in the sectors generated by the movement of the gates. This is no small factor in the resistance to motion. So great is the power required to start the gates in motion, that, should a difference in head of more than 1½ ins. exist between the water in the chamber and that in the canal, the power at present available is insufficient.

As the chamber is being filled, and the difference in head decreases, the flow decreases in velocity and in volume; and when the chamber is nearly full, say when there is a difference in the levels of but one foot, the flow is very slow, and much time is consumed in waiting until the difference in the levels is reduced to 1½ ins., at which time and not sooner, as above stated, the power is sufficient to set the gates in motion.

The time required for filling the lock averages ten minutes, and that of emptying about eight minutes. In addition, it requires about two minutes to open or close the gates, due principally to the resistance of the water. After a vessel enters the lock chamber, she must come to a full stop and tie up to the side before water is allowed to enter, and must remain at rest until the filling or emptying is accomplished. Then the vessel must cast off and get under way. These delays will be more fully dwelt upon further on in this article, and are mentioned at this time merely to show the reasons for the length of time required to lock through the Poe.

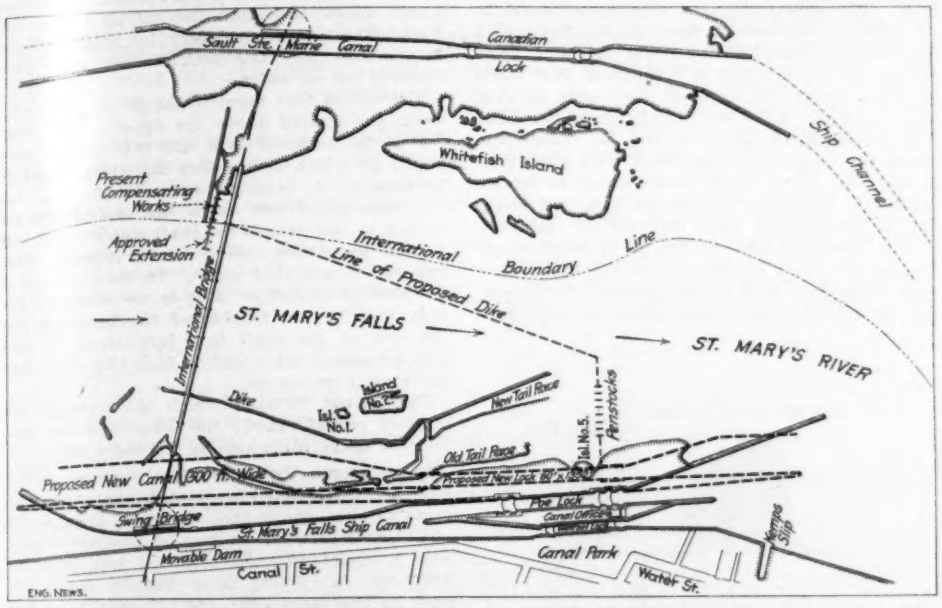



FIG. 1. MAP OF ST. MARY'S RIVER AT HEAD OF RAPIDS SHOWING PRESENT AND PROPOSED LOCKS AND OTHER IMPROVEMENTS.

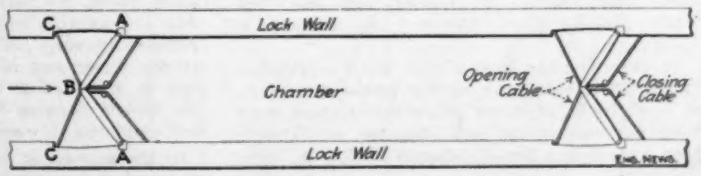



FIG. 2. DIAGRAM PLAN OF POE LOCK.

The lower approach pier lies at an angle of about 25° to the axis of the canal; and in entering from this pier, up-bound vessels head directly toward the left-hand gate. This requires them to turn at such a sharp angle that, in order to accomplish the turn and avoid injury to the gate, it is often necessary to back the boat, as pier suction, caused by the shallowness of the water, together with slow speed of the vessel, will not allow them to straighten for the entrance.

In the spring, the current produced by filling the lock draws all the ice in the canal down to the lock gates, where it has to be removed with pike poles having lines attached, piece by piece, before the gates can open. A down-bound boat will push this field of ice ahead of her, and jam the ice against the lower gates. When the boat is lowered, the ice must be removed from behind the gates with 30-ft. poles (lines attached) before they can be opened. It has happened that the boat has had to be locked back up again, and the ice locked through, out of the way, before the boat could be passed through. The gate to be described in this article will entirely overcome this difficulty.

It may be said that this delay by floating ice occurs only in the spring or fall, when navigation is light, and so is of little consequence. Notwithstanding the comparative lightness of navigation, however, the fact remains that much time has been lost by boats due to the presence of floating ice in the canal. In the fall an hour's delay might be the cause of one or many boats not being able to reach their home port that season on account of freezing weather.

Another important factor in the length of time required to lock through the Poe, is the one mentioned above, that all boats locking must tie up before the valves are opened to fill or empty the chamber, as the case may be. This is necessary on account of the surging of the water in the lock chamber when filling or emptying, and the excessive time required for the operation of the gates. Much time is consumed in getting the boat under way, due to poor water circulation, on account of the proximity of the boat to the lock floor and to the wall to which she is moored. In a wide lock like the Poe, when a boat moves her wheel to go ahead, water can only circulate to the wheel (if she works a strong wheel) from the open side. This creates a pressure from that side, forcing her stern against the wall with such force that the friction between the boat and the wall overcome its propelling power. The result is that, in order to get out of the lock, she must use a backing wheel to throw her stern away from the wall, and then move ahead on a very slow wheel or heave ahead with cable by windlasses, either of which is a very slow process.

Unfortunately these delays do not affect the boat locking through alone, but all coming boats as well, no matter how far back, until there is a break in the traffic or lapse of time of sufficient length to equal the delay of all the unlocked boats going in the same direction. Even a minute's delay will affect all coming boats during a day, a week, a month, or the season in fact, if the break referred to does not occur. For this reason, engineers should cut out every minute's delay, no matter from what source, and lock the traffic through without loss of time, a feat that is quite possible, as will be shown.

Another bad feature of the present system is what is called the "back set" in the canal above the lock. During the process of filling there is a strong current created in the canal. This current continues for some time after the lock is full, causing the water to rise about 2 ft. above the normal level before it ceases. The back set then takes place with great force, tearing boats from their moorings and doing damage in many ways.

So much for the Poe, which, as previously stated, is acknowledged to be the best type of lock in operation to-day. The author has designed, and will attempt to explain, a lock which he believes will overcome the defects noted.

It is proposed to construct a lock parallel to and on the northerly side of the Poe, to meet the

*Engineer, Iron County Road Commission, Crystal Falls, Mich.

demands of the constantly increasing traffic. For the sake of brevity, the lock which the government has approved for this location, will be referred to as the Davis Lock, it having been designed under Col. C. E. L. B. Davis, of the United States Engineering Corps; and the lock which the author has designed will be referred to as the author's lock.

The author's lock is 850 ft. long; the Davis is designed to be 1,350. The advantages to be gained from constructing a lock longer than 850 ft. are comparatively small. The disadvantages are many, and, among others, may be mentioned the following:

1. TIME OF FILLING AND EMPTYING.—The time of filling and emptying is directly proportionate to the length of the cross-section of the lock chamber, and area of the filling ports remains constant. Should the attempt be made to fill the longer lock in the same or less time by increasing the size of the inlet valves, in a canal constructed on the plan of the Poe, as the Davis is designed to be, the result would be to increase the rapidity of the current in the approach, which, as has been shown, is already a serious objection.

2. TIME OF PASSAGE.—The average speed in the lock chamber, of vessels of the larger type, is about 100 ft. per minute. Therefore, for every 100 ft. in length that the lock exceeds the short one, so many more minutes will be required to make a lockage. Let us assume that two boats of the 600-ft. class are about to lock through the Davis. The boats alone occupy 1,200 ft. of lock space, leaving 150 ft. for operation of the lower gates and clearance. The operation of the gates will require very nearly 50 ft., so that the clearance is scarcely more than 100 ft. The navigator of No. 1 must get as close to the forward gates as possible to make room for No. 2. To move a vessel of this size under her own steam in such close quarters is a dangerous proceeding, and to obviate this danger, the boat is run close to the lock wall and is then slowly pulled ahead by means of her deck engines and cables. The navigator of No. 2 will not attempt to enter the chamber until No. 1 has made fast. No. 2 must also be propelled by the same method, keeping a safe distance from No. 1, whose "fan tail" must be respected, as were the gates by No. 1. This method of propelling a vessel by her deck engines results in excessive wear and tear on both machinery and cable, amounting in a year to a large item, and also a great loss of time.

3. COST OF CONSTRUCTION.—The longer the lock, the more masonry will be required in the chamber walls, and the more excavation in the approach to overcome the increased current caused by the filling. This excess of masonry and excavation add, of course, to the cost of construction, the appropriation for which, in the case of the Davis lock, is $1,200,000.

4. TIME OF CONSTRUCTION AND COMPLETION.—The time of completion is another important point to be considered in a discussion of the relative merits of the two lengths of lock. The congestion at the Soo already demands speedy relief, and the sooner the new lock is completed, the sooner will conditions be improved. It seems hardly necessary to state that a lock 850 ft. long could be constructed in less time than a lock of 1,350 ft. long.

As shown in Fig. 1, a dyke could be built impounding all the water that now passes between the boundary line and the Michigan shore, with the exception of that which passes through the lock. The construction of this dyke would be no difficult engineering feat, as the bottom of the rapids is rock, and the water only 4 ft. deep. During its construction a temporary dam could be built across the head of the rapids to shut off the water. After the completion of the dyke, with penstocks in the lower end for power purposes, the dam could be removed. This would give a side bay, from which water could be drawn to operate the author's proposed lock. All water not so used would pass through the penstock at the lower end and, with a 20-ft. head, would develop far more power than would be possible with a power canal under present conditions; and the power so generated could be utilized to operate the gates, furnish light for lighting the canal, etc.

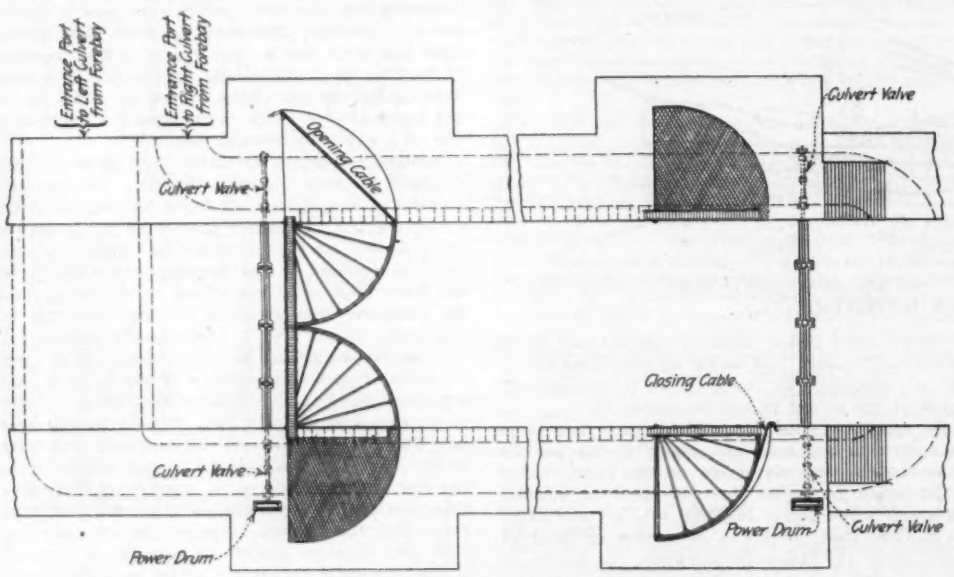



FIG. 3. GENERAL PLAN OF "AUTHOR'S" PROPOSED LOCK.

The heavy lines on the drawing show the proposed Davis canal, with its approach piers, etc. As the water to be used in the operation of the author's lock comes from the side bay, there will be no current in the upper approach. This will reduce in size the 300-ft. approach necessary in the Davis canal, eliminating a large amount of rock excavation. The saving thereby affected could be applied to the construction of the dyke, as could also the saving effected by keeping down the length of masonry in the lock walls, making them 850 ft. long instead of 1,350 ft.

To overcome the lack of free water circulation in the old system, the author proposes to have at least 10 ft. of water below the deepest draft boat, not only in the lock chamber, but also in both approaches for a distance of 500 ft. from the gates.

To overcome the current in the approach, and with it the presence of an excessive amount of floating ice in the lock chamber (which, however, in case of the author's proposed lock will be no serious objection) the water to operate the lock will be drawn from the forebay by means of culverts in the lock walls, and fed as noted above, laterally through ports or openings in the walls of the lock chamber. This method of filling also dispenses with the necessity for the false bottom, and with part of the excavation, thereby further reducing the cost of construction, which saving could also be applied to the cost of building the dyke mentioned above.

The cost of constructing the walls containing culverts will not exceed that of constructing the present solid walls, in that the culverts displace an amount of masonry, the cost of which would be sufficient to pay for the construction of the culverts over the cost of solid masonry.

The water enters from the side bay directly into the right hand culvert. (See Fig. 3.) The left-hand culvert is filled through a port 10 ft. deep and 100 ft. wide, rectangular in shape, which extends directly through the right-hand lock wall, across under the canal above the upper gates, then into the culvert in the left wall. There is no necessity for great strength in the floor over this port, the port being continually full of water.

The valves that regulate the filling of the culverts are located above the upper gates. They are of the balanced type and both on the same shaft, by which means they are operated simultaneously. A balanced valve is one that has the area above and below the axis of rotation (which in this case is the shaft mentioned above) in such proportion that the water pressure above the axis equals that below. To the operation of a valve of this type there is no resistance except that of the friction of the bearings. On the end of the shaft is a large drum, around which passes a cable leading from the power that operates these valves.

The valves through which the culverts are emptied are of exactly the same type and size, and are operated in exactly the same way.

To overcome the longitudinal current in the chamber, it is filled as stated above, through ports or openings in the side walls, of such size and at such intervals as may be determined upon, with a combined cross sectional area of about 1,600 sq. ft. Being filled equally from both sides at the same time, the tendency is to hold a boat in the middle of the chamber.

The openings in the masonry at the end of the chamber, A Z, are of the same size. (See Fig. 4.) As the center of the lock chamber is approached, the openings decrease in size. It follows, of course, that the center opening, M, is the smallest.

With no further provision for filling or emptying, there would be a tendency for the upper end to fill faster than the lower, and the lower to empty faster than the upper, causing longitudinal currents in the chamber, which is the very thing sought to be overcome. In other words, when filling, the ports at the upper end of the chamber should be smaller than the ports at the lower end, and when emptying, the ports at the lower end should be smaller than those at the upper end.

To accomplish this, each opening in the masonry (except as shown below, the opening M) is provided with a trunnion valve. All valves above the center open outward freely, but do not open inward. All valves below the center open inward freely, but do not open outward. These valves are hung above the center of gravity, so that when the water is at rest they are closed by gravity. They are so regulated in size that when filling, the port at the upper end is smallest, and as the lower end is approached they increase in size; and when emptying the port at the upper end is largest, and as the lower end is approached, they decrease in size. As the middle opening is the mean in both filling and emptying, it requires no valve.

In the process of emptying, it may be well to state what has already been implied, that the water passes out through the same ports, into the culverts, and out through the balanced valves just below the lower gates.

As shown above, the Poe lock requires ten minutes to fill and eight to empty. In the author's proposed lock, where the ports are made of sufficient size (taking into consideration the coefficients of efflux, or reduction in cross-section of flow where valves would interfere with a rounded approach, both emptying and filling) to take care of all the water flowing into the culverts from the forebay, the time of filling,

using the following formula (Church) is computed as follows:

Time of filling in seconds

$$= \frac{2 \times \text{volume of chamber}}{C F \sqrt{2 g h}}$$

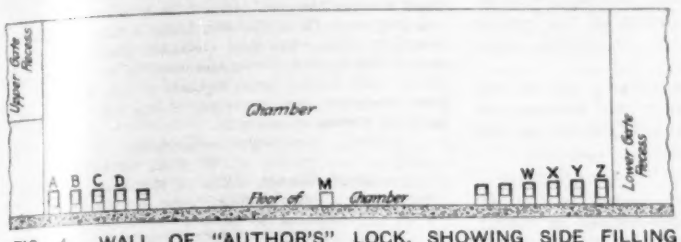



FIG. 4. WALL OF "AUTHOR'S" LOCK, SHOWING SIDE FILLING OPENINGS.

in which

$F$ = combined area of culverts = 1,600 sq. ft.

$g$ = acceleration of gravity = 32.2 ft. per second.

$h$ = height of head at beginning of flow = 20 ft.

$C$ = coefficient of efflux, which, according to Trautwine, is the same under water as in air. Assuming that $C$ is .80, we have

Time of filling in seconds

$$= \frac{2 \times .80 \times 850 \times 20}{.80 \times 1600 \sqrt{2 \times 32.2 \times 20}} = 59.4,$$

or practically one minute. Allowing 25% for unknown actions tending to reduce the flow and increase the time of filling or emptying, we will still be able to accomplish either in the almost incredibly short time of 1 minute 15 seconds.

Using the same formula to compute the time required to fill the last 18 ins. in the chamber, we find that the time required is 15.2 seconds. We will later show that the gates can be opened against any head, and it is the author's plan to start then to open when the difference in head is 18 ins., which will again reduce the time to practically one minute from the time the ports are opened to fill or empty until the gates are opened to allow the vessel to pass out into the river. The operation of the gates against an 18-in. head would not result in an avalanche of water pouring in, but there would be simply an 18-in. layer at the moment the gates are opened, flowing on top of the water already in the chamber, practically 50 ft. deep, which layer would constantly decrease in velocity and in volume until a level was obtained. This flow would scarcely be felt by the smaller craft, and would not be noticeable at all by large freighters.

When the head is reduced to the last 18 ins., it is the author's plan to have a gong ring, which would be a signal to the navigator of a boat that the gates were about to open. He will then ring for increased speed and proceed out of the chamber. It will thus be seen that a vessel locking through the author's lock need not stop to tie up at all, but can keep moving all the time at a speed of not less than 100 ft. per minute.

The gates in the author's lock consist of a water-tight skin, curved to an arc of the spiral of Archimedes (watch spring) for a reason to be given later. This skin is held to the axis of rotation, or post, by means of radial tension spokes, the shorter leading from the toe, A (Fig. 5), and the longer from the heel, B. With the exception of this skin, the gates are of skeleton construction, thereby allowing the water in the chamber to move freely behind them (among the spokes) and into the gate recess.

From the toe to the post on the upper side of the gate is a screen (Fig. 3) to prevent floating ice from getting among the spokes or in the recess back of the gate; because the presence of ice or other material among the spokes would tend to retard the operation of the gates, and the presence of solid matter in the recess would prevent complete opening.

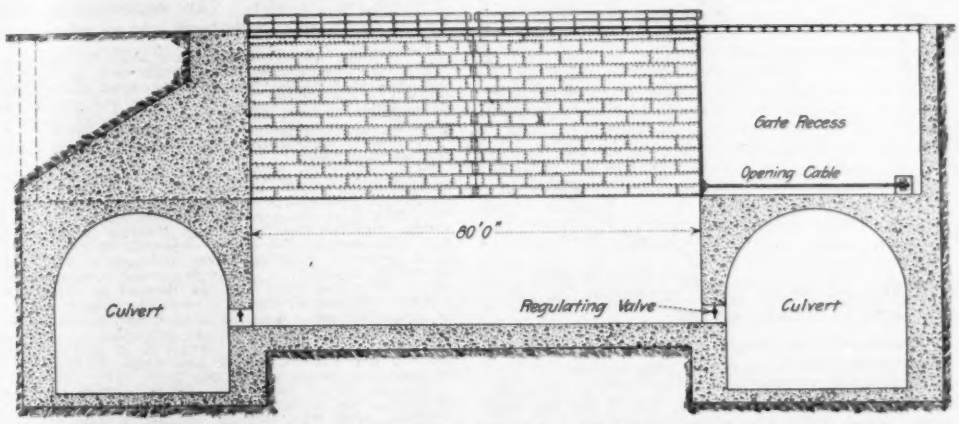



FIG. 4A. CROSS-SECTION OF "AUTHOR'S" PROPOSED LOCK SHOWING CULVERTS FOR FILLING AND EMPTYING.

The spiral form of skin is adopted instead of the circular form for the following reason: All liquid pressures are normal, or perpendicular to the sides of the retaining vessel (Fig. 6). The pressure exerted by the water, P, P', P", P'", — —P', on a circular skin, being normal, will lie in the direction of the radial spokes; and R, the resultant of these pressures, will pass through the post, or axis of rotation, the same being the center of curvature.

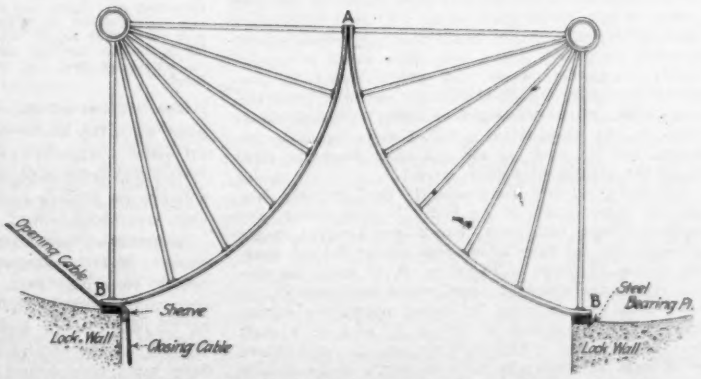



FIG. 5. PLAN OF "AUTHOR'S" PROPOSED LOCK GATES.

In Fig. 6, the skin being an arc of a spiral the pressure will not follow the direction of the spokes, but the resultant of all the pressures, R, will pass to the side of the turning axis, and produce a turning moment, Ra, about the axis, which will tend to keep the gate closed under a head. This is an advantage in that, should the closing cable part, the gates would remain closed and maintain the upper level.

The magnitude of this spiral should not be such as to create an excessive turning moment, as this would require too much power to operate the gates against head, with no resultant benefit.

The skin does not engage with the lock wall until the gate is closed. Then a steel sliding plane at the heel (Fig. 5) comes against a similar surface, set vertically in the lock wall. When the gates are closed, the pressure exerted by the water above tends to force the heel around further on the sliding plane and to force the gates up-stream, thereby relieving the axis of the down-stream tension, which is now transmitted to and borne by the bearing plate, extending the entire vertical height of the gate. This plate, being set in solid masonry, is abundantly able to withstand the pressure. The same conditions obtain directly across the lock chamber at the heel of the opposite gate.

The water pressures at the toes are equal and applied opposite. This keeps the gates water-tight at the center, or toes, and any wear on the surface at this point may be taken up, or compensated by adjusting a wooden cushion or plank put there for that purpose.

Let us suppose the gates to be closed, and the water above at high level. The heels of both are bearing firmly against the steel plate. The toes are pressed firmly together by equal forces, viz.: the water pressure on each side of the point of contact. We then have a balanced system such that, should this skin be sufficiently trussed to withstand the pressure of the water without the spokes, the latter could be cut away, and, assuming that the bearing plates have a proper angle proportioned to the turning moment of the spiral of the gate, the balanced system would still remain.

This gate has, however, been criticised, on the ground that the shear on the swinging post, or axis would be so great as to render it impossible to anchor it to the wall sufficiently strong to enable it to withstand the strain of supporting the head. Also, because the shear on the bearing or hinge would be so great as to cause it to wear out quickly.

It is submitted that these objections are untenable, because, in the operation of the gates, practically no water is fanned, and the only resistance met with is that of the forward edge of the skin, and the spokes, cutting their way through the water. And as to wear on the hinge, it must be remembered that the gates are not operated against a greater head than 18 ins. at any time.

The power for opening the gates is applied through a cable attached to the heel, leading to a sheave in the back angle of the gate recess. The power for closing is applied through a cable attached to the heel, leading around a sheave in the lock wall. No mechanism is used to lock the gates when closed, the water pressure and closing cable performing that function.

A vessel striking the gates from above, in order to open them, must strike with a force sufficient to break the cable, which force must be greater than the strength of the cable, since the spokes at the toe are shorter than those at the heel, and also because of the turning moment mentioned above. To protect the gates from such possible impact, a fender could be placed along the upper side of the gate; therefore, no harm, other than a slight delay, could come from the gates being opened in this manner. Again, since the chamber is filled from the forebay, and the filling of it causes no current in the upper approach, the danger of boats striking the gates from above is practically eliminated.

There is no danger of the gates being struck by an up-bound vessel, provided proper speed regulations are observed. But, should it be seen that a boat locking up might strike the gates, they could readily be partially opened, and the rush of water would check her advance, after which they could be closed again; or, if the head

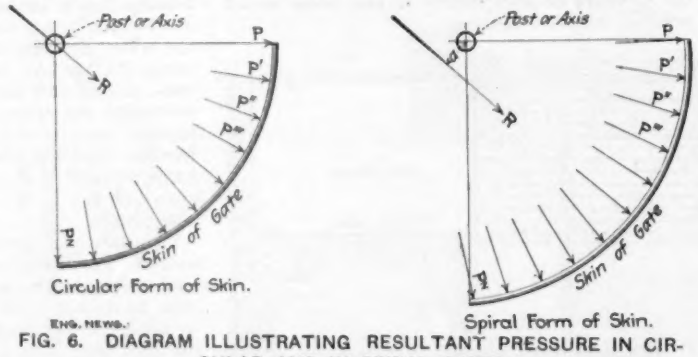
were not too great—or not great enough so that the water would check the advance of the boat—they could be entirely opened and the vessel allowed to proceed.

The ability to open and close the gates against any head whatever does away, also, with the necessity for a movable dam, which exists in the case of the Poe; because, should a down-bound boat carry away the upper gates in the Poe, the water would enter and travel through the chamber with a force sufficient to carry away the lower gates also. Without the movable dam in such an emergency the water would be given free passage through the canal, and the current would be so great that neither navigation through St. Mary's River, nor the repairing of the gates, would be possible. And the movable dam, if it were ever used, would also close the entrance to the Weitzel lock, throwing the entire burden of navigation on the third lock until the gates were repaired.

Let us assume that a boat of the 600-ft. class, is about to pass up through a lock of the author's design. The moment the stern is clear of the lower gates, they are closed, and the valves leading from the forebay into the culverts are opened. Assuming that it will require 50 ft. of lock space to operate the upper gates—which allowance is liberal—the boat still has 200 ft. to travel to reach them. At the average locking speed of 100 ft. a minute, this will take two minutes. The chamber is filled to within 18 ins. of the top in one minute, when the gong rings and the upper gates open, with the bow of the boat still 100 ft., or one minute, distant.

In locking down, the same process is gone through, in the same period of time.

It is conservatively estimated that this lock will easily handle six lockages per hour, whereas the average time of the Poe, as stated above, is 35 minutes 9 seconds. A quick operating lock of this type, working in conjunction with the Poe and Weitzel locks, would be ample to meet all the demands of navigation for a long time to come. And should the time ever come when the facilities thus afforded would be inadequate, the Poe could, at comparatively small expense, be changed into a quick operating lock, and the two could easily handle all the traffic that can safely navigate the St. Mary's River.




ENG. NEWS.

FIG. 6. DIAGRAM ILLUSTRATING RESULTANT PRESSURE IN CIRCULAR AND IN SPIRAL GATES.

**Summary.**

To sum up, it may be briefly stated that there are three available essentials which, if utilized, will triple the efficiency of the new lock. They are:

1. Deepening of the lock and the immediate approaches sufficiently to admit of free water circulation under and around the boat. This would eliminate what is known as pier suction, and allow the boat to answer her helm when she moves with reasonable speed out of the lock, which boats cannot do under present conditions.

2. Taking the water for filling from a side bay, where it can be drawn fast enough to fill the lock in about one minute, instead of from the canal.

3. The use of balanced suspension gates which can be opened while there is yet a head of water on, or closed against the full head of 20 ft. with the water flowing through the lock. The adoption of this type of gate would remove the ever-threatening possibility of the gates being carried away, as they could stand the impact of a boat striking against them (being properly fendered with oak, as stated above) without any damage whatever to themselves; for if struck with a force sufficient to destroy the present gates, they would simply open and let the boat pass through.

With these suggestions made, and the certain advantages of the type of lock herein proposed over the present system, it is hard to understand why the engineers do not adopt this new design. Their attention was called to the matter by a comprehensive article in the "Marine Review" in September, 1906, written by R. J. McKeone, one of the Assistant Superintendents at the locks, who had studied the question and saw the need and possibility of improvement. The logic of that article prompted the author to contribute his mite upon the subject while yet in time to be of value.

The suggestions herein made as to type of lock could be utilized as readily in the Panama, or any other canal to be constructed, as in the one at Sault Ste. Marie.

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[We submitted the above paper to Col. C. McD. Townsend, the Engineer Officer in charge of the Detroit District, with invitation to comment on the ideas suggested by Mr. Burley. We have been favored with the reply printed below.—Ed. Eng. News.]

Sir: I have read "A Suggestion of Type of Lock for the New Government Canal at Sault Ste. Marie" with considerable interest. The paper at least contains many novel suggestions, and as you propose to publish it I have no objection to submitting the following.

The Poe lock has been considered a fairly good lock by most engineers, but it unquestionably has defects, and I am thoroughly in accord with the writer that if those defects can be corrected, the new lock should be constructed so as to eliminate them. If a lock can be built through which a boat can pass without stopping and gates constructed that will retain water under a head of 20 ft., yet when struck by a vessel open so as to prevent injury to the gate or vessel, it is an advance in engineering worthy of serious consideration.

The filling of the Poe lock in ten minutes is an improvement on European practice, but to cut the time down to one minute and fifteen seconds with safety to a boat in the lock would be also desirable. There are, however, several practical objections to the scheme proposed. Lock gates are usually constructed so that the strains transmitted through them are those of compression. In the Poe lock they form an arch, and the greater the pressure against them, the more powerfully they are forced against the quoin recesses and miter sills. The only way the gates can yield is by crushing. The writer proposes to reverse these strains to those of tension, by turning the gates around so that their convexity is down stream and transfers the tensional strains to posts anchored to the masonry, relying on a couple of cables and a delicate system of balanced pressures to keep the gates closed. If water at the rate of from 20,000 to 30,000 cubic feet per second should suddenly be poured into a lock there would be considerable commotion, water ram effects would be produced that might interfere with the balanced pressures, and if one of the cables should break, as cables sometimes do, the gates might suddenly move into their recesses, and the boats in the lock start down the river under the impetus of a 20-ft. wave.

Side-filling culverts are frequently used in locks, and are not objectionable if the filling is done slowly, and uniformly from both sides, but if any accident should occur so that the valve of one side culvert did not work, the sudden discharge of 10,000 cu. ft. of water per second against the side of a vessel would cause trouble. To avoid such a catastrophe the writer places two valves, apparently with an area of 800 sq. ft. each on a shaft over 100 ft. long. This will require the expenditure of at least 20 times the force necessary to manipulate one of the valves in the Poe lock, which are themselves rather large balanced valves. Culverts can be constructed more cheaply at the side of a lock than under it, but if placed as low as the writer proposes, the saving in cost of construction will be slight. The arrangement of ports is ingenious, but is not considered necessary.

The question of filling the lock from a forebay, instead of the canal, is at present being [illegible] stigated by the undersigned, as directed in the la[illegible]er and harbor act. The advantages of such a met[illegible]f filling are obvious, the principal disadvantages are [illegible]terferences with the construction of a fourth lo[illegible] it should ever be required and the additional co[illegible]\ sufficient forebay will be constructed to produce p[illegible] to run the canal whether the lock is fed from it or [illegible].

A greater depth in the lock means a c[illegible]onding increase in cost. Ten feet clearance ap[illegible] excessive. A lock 850 ft. long will unquestionably [illegible]aper than one of 1,350 ft., but under methods of lock[illegible]ration that have heretofore been accepted, it will not [illegible]k through as many vessels at one time.

Very respectfully,

C. McD. Town[illegible],

Lieut.-Colonel, Corps of Engineer[illegible], U. S. A.

Jones Bldg., Detroit, Mich., June 1, 1909.

## The Report Upon the Proposed 14 ft. Deep Waterway from Chicago to New Orleans.

For several years past there has been popular agitation over the proposal to create a deep waterway from Chicago down the Illinois and Mississippi Rivers to the Gulf of Mexico. The slogan of the agitators has been "Fourteen feet through the Valley."

Two years ago Congress provided in the River and Harbor Bill for a survey and report upon this much discussed project. It was ordered that a Board should be appointed by the Secretary of War, made up of three members of the Mississippi River Commission and two officers of the Corps of Enginers, U. S. A., to survey and report upon this project, its cost, its feasibility and its advisability. The detailed instruction in the River and Harbor act was as follows:

To examine the Mississippi River below St. Louis and report to Congress, at the earliest date by which a thorough examination can be made, upon the practicability and desirability of constructing and maintaining a navigable channel 14 ft. deep and of suitable width from St. Louis to the mouth of the river, either by the improvement of said river or by a canal or canals for part of said route.

In its report the board shall cover the probable cost of such improvement, the probable cost of maintenance, and the present and prospective commerce of said waterway, both local and general, upstream as well as downstream, and the said board may consider in connection with the examination herein provided for, the survey of a proposed waterway from Chicago to St. Louis, heretofore reported; it shall also report whether other plans of improvement can be devised by which the probable demands of traffic, present and prospective, can be adequately met. Said board shall also at the earliest date practicable report upon the following:

"First. What depth of channel is it practicable to produce between St. Louis and Cairo at low water by means of regulation works.

"Second. What depth will obtain in such regulated channel at the average stage of water for the year.

"Third. For what average number of days annually will 14 ft. of water obtain in such regulated channel.

"Fourth. What increase of depth will be obtained over the natural flow of water in such regulated channel by an added volume of 10,000 cu. ft. per second; also 14,000 cu. ft. per second.

"Fifth. And the board shall consider further the practicability of producing at all seasons of the year a depth of 14 ft. in such regulated channel by the aid of locks and dams similar to those projected and in use on the Ohio River improvement.

"Sixth. And the said Board shall also report upon any water power which may be created in the portion herein directed to be surveyed, as well as in the proposed waterway from St. Louis to Chicago heretofore surveyed, and the value thereof, and what means should be taken in order that the Government of the United States may conserve the same or receive adequate compensation therefor, and upon any lands which may be drained by the construction of either of said proposed waterways, and shall also report what steps, if any, shall be taken to cause the cost of the improvement to be defrayed, in whole or part, by means of such water power or lands."

The Report of the Board appointed in accordance with the above was transmitted to Congress on June 7 accompanied by a further report and recommendations from the general Board of Engineers on Rivers and Harbors and comment by Gen. Marshall, Chief of Engineers.

In general the report indicates that the projected 14-ft. waterway would be enormously costly to make and to maintain, yet its construction would probably be feasible if the benefit to result were sufficient. But the Board indicates in the strongest terms that the proposed deep waterway would not carry the traffic which its promoters anticipate, and that it would practically be no more serviceable to commerce than a waterway 8 to 9 ft. deep which could be built at a small fraction of the cost, and indeed already exists over the greater part of the route.

These reports are of such great interest and importance that we have taken space to print

them [illegible]ly in full below. We have commented upon [illegible] in our editorial columns.

## REPORT OF THE SPECIAL BOARD OF ENGINEERS.

St. Louis, Mo., March 20, 1909.

General:

The Board created by Act of Congress approved March 2, 1907, to make an examination of the Mississippi River from St. Louis, Mo., to its mouth, having completed the investigations and studies assigned to it, has the honor to submit the following report.

While the Board has been aware of the importance of submitting its conclusions at as early a date as practicable it has considered the problems assigned to it of such vast importance to the country and so difficult of solution as to warrant most careful consideration in preparing a report. A report of field and office operations under the Board is given in Appendix No. 21. To comply with the Board's interpretation of the law, required surveys and investigations that necessarily involved a greater time than was at its disposal prior to the first Monday in November, 1908. These surveys were completed in January, 1909, and the Board has submitted its report as soon as it was practicable to analyze the data before it and formulate its conclusions.

The data of the Mississippi River Commission, placed at the Board's disposal by law, give much valuable information in regard to the physical characteristics of the entire stretch of river under consideration, and the records of the U. S. Engineer Office at St. Louis added much for the portion from St. Louis to Cairo. The Board, however, found it necessary to augment such information by a comprehensive survey of the river between St. Louis and Cairo, including topography, hydrography, and an investigation of the depth of bed rock and character of overlying strata; to extend this survey over the entire breadth of the alluvial valley from St. Louis to Cairo; to make a survey of caving banks between Cairo, Ill., and the mouth of the Red River, and also to determine the number of bars below Cairo having less than 14 ft. channel depth.

The survey above Cairo was begun with all available plant. Field work covering some 200 miles of river and 600 sq. miles of valley with 136 borings, part in the river and part on land, was finished Aug. 10, 1908. Below Cairo the work could not be completed until the end of the dredging season, in January, 1909.

### Description of the Mississippi River.

The physical characteristics of the Mississippi River are described in Appendix No. 1 of this report.

Ice influences extend as far south as Memphis, interrupting navigation at St. Louis about one month a year. Below Cairo interruptions occur in but occasional years, and for but a few weeks.

As to soil and foundations, it appears that the average depth of bed rock below low water is between 50 and 100 ft. between St. Louis and Cairo and much greater below Cairo. The margin for securing a 14-ft. waterway by deepening its channel is thus ample without recourse to rock excavation. Only at one place, between Thebes, Ill., and Commerce, Mo., was bed rock disclosed within 20 ft. of the low-water surface, and even there it appears that there is a margin of at least 17 ft. below low water over a width of at least 500 ft. On the other hand, the overlying strata were found to be unsuitable as foundation for such heavy structures as fixed dams; and only in the stretch between Thebes and Commerce, where this bed rock existed near low water, could suitable foundation be found at a practicable depth.

As to the hydraulics of the river; the variation in the low and high water widths along the course of the river is extreme. Above the mouth of the Ohio River low-water widths have been found ranging from 650 ft. to 4,000 ft., and bank-full widths from 1,550 ft. to 6,800 ft. Below Cairo low-water widths range from about 1,000 ft. to about 6,000 ft., and bank-full widths from less than 2,000 ft. to over 10,000 ft.

The area subject to overflow has been much decreased of late years, especially below Cairo, by the construction of levees. It was formerly about five miles in width between St. Louis, Mo., and Grays Point, Mo., where the bluffs on either side come close to the river banks and continue so as far as Commerce; below Commerce the area subject to overflow averaged some 40 miles in width, but through the restriction of floods by levees the area above Red River is now but five to ten miles wide, except at the mouths of the larger tributaries where the levee system is incomplete.

The average slope of stretches of the river at high and low stages is given in Appendix No. 1 in tabular form. The maximum slope occurs between St. Louis and Cairo, about 0.6 ft. per mile, gradually decreasing to a high-water slope of about 0.2 ft. and low-water slope of about 0.025 ft. between Red River and Carrollton, La. Below the latter point the low-water slope is eclipsed by tidal oscillations and the high-water slope is about 0.1 ft. per mile.

The average depths along the thalweg of the stream are at low water about as follows:

| | |
|---|---|
| St. Louis to Cairo | 18 ft. |
| Cairo to Memphis | 31 ft. |
| Memphis to Vicksburg | 37 ft. |
| Vicksburg to Red River | 48 ft. |
| Red River to New Orleans | 84 ft. |

A natural 14-ft. channel obtains between St. Louis and Cairo for an average period of about 1½ months, during the months of April to July. Below Cairo the period is much greater, lasting from about January to July, sometimes beginning in December and sometimes lasting into August.

It is an important fact that a rise in stage does not produce a corresponding increase in channel depth, for example a 22-ft. stage of water at St. Louis does not produce more than 14-ft. available depth between St. Louis and Cairo.

### Present Projects for Improvements.

BETWEEN ST. LOUIS AND CAIRO.—The present project is that adopted in 1881.

This project contemplated the confinement of the flow of the river to a single channel having an approximate width of 2,500 ft. at bank-full stage, this result to be sought by closing sloughs and secondary channels and by building out new banks where the natural width is excessive, using for this purpose permeable dikes or hurdles of piling to collect and hold the solid matter that is held in suspension or rolled on the bottom of the river; the banks, both new and old, to be revetted or otherwise protected where necessary to secure permanency. The object of the improvement was to obtain ultimately a minimum depth, at standard low water, of 8 ft. from St. Louis to Cairo.

Modifications of the project in the River and Harbor Acts of 1896 and 1902 provided that pending the completion of the permanent improvement, the low water channel would be improved by the use of dredges and other temporary expedients, but the River and Harbor Act of March 3, 1905, made a radical departure from the project above outlined, practically confining the work of improvement to dredging.

The River and Harbor Act of March 2, 1907, reaffirmed dependence upon dredging as the principal means of improvement; although, as subsidiary thereto, it provided also for the maintenance and repair of existing works of permanent improvement and finally for the construction of similar works, with any portion of the appropriation not necessary for the accomplishment of the improvement by dredging. But as the annual appropriation was reduced to about 40% of that theretofore made, the expenditure in any one year being limited to about $250,000, the only work in present progress is that of dredging.

BETWEEN THE OHIO RIVER AND THE HEAD OF PASSES.—The improvement of the Mississippi River below Cairo has been in charge of the Mississippi River Commission since 1879. The original project submitted by the Commission provided for the narrowing of the low-water channel-way to an approximately uniform width of 3,000 ft. by means of dikes and the revetment of caving banks; these works to be supplemented by levees to confine the flood discharge of the river approximately to its river bed.

The work of improving Plum Point and Lake Providence reaches was undertaken, and the highly beneficial results obtained in improving channel depths in those reaches confirmed the soundness of the theory upon which the work was based, but also demonstrated that the permanent improvement of the channel by contraction and revetment works would necessarily consume a long period of time.

The Act of Congress approved June 3, 1896, authorized the use of hydraulic dredges for obtaining and maintaining a channel in the Mississippi River below Cairo with a width of 250 ft. and a depth of 9 ft. throughout the year, except when the river is closed by ice; and since their construction ten hydraulic dredges have succeeded in maintaining the project depth and width except for short periods in 1903, 1904 and 1908.

### Practicability of Constructing and Maintaining a Navigable Channel 14 Ft. Deep.

The survey for a 14-ft. waterway from Chicago to St. Louis, made by a special Board which reported in 1905, provides for a channel in the Illinois River with a bottom width of 200 ft., and in the canal section a width of 160 ft. For the gentle slopes that will exist in the Illinois River and in the canal, the Board is of the opinion that these widths will afford a channel that it is practicable to navigate; but that to provide as effective navigation in the swift currents of the Mississippi will require channel widths not less than 500 ft.

To obtain and maintain the 14-ft. channel on which the Board has to submit its report, the following methods have been suggested and considered:

1. Dredging.
2. Regularization.
3. Canalization with movable dams.
4. Canalization with fixed dams.
5. Lateral canals.
6. Reservoirs.
7. Combination of methods.

DREDGING.—The surveys of the Board show that between St. Louis and Cairo there existed in 1908 as many as 68 localities that would require dredging to obtain a 14-ft. channel, and that to dredge a channel 500 ft. wide and 14 ft. deep at low water would necessitate the removal of 35,000,000 cu. yds. of material. Channels thus formed would have a tendency to refill, not only on every rise of the river, but on any change in the regimen such as would be produced by an ice gorge; so that extensive dredging operations would be required not only on a falling river, but every spring on the opening of navigation.

To cover such dredging, a project has been prepared which shows that to insure the maintenance of such channels so that navigation will not be obstructed would require a plant capable of removing about 17,500,000 cu. yds. per month. This would necessitate the acquiring of 20 dredges of the type at present used on this stretch of river, with its accompanying plant, at an estimated cost of $6,000,000. The cost of operating and maintaining such a plant is estimated at $2,000,000 per year. The estimates are based upon ten years' practical experience with the St. Louis Engineer District dredging plants in this part of the river.

From Cairo to the mouth of Red River, below which an ample depth of channel exists, the surveys made by the Board showed 42 localities in 1907 at which dredging would have been required to obtain a 14-ft. channel, and 88 localities during the season of 1908. The period during which dredging operations are required to maintain channels is however much shorter in the lower river than above Cairo.

To cover such dredging a project has been prepared which shows that a 14-ft. waterway can be maintained between Cairo and Red River by 28 dredges with their accompanying plant, at an estimated first cost of $9,000,000, and an annual expenditure of $2,100,000 for operation and maintenance. These estimates are based upon many years' experience of the Mississippi River Commission in this part of the river.

REGULARIZATION.—Both the project of 1881 for improving the river from St. Louis to Cairo, and that of the Mississippi River Commission from Cairo to the Gulf, originally provided for its improvement by partial regularization. The river was to be confined to a single channel, caving banks revetted, and the width of channel contracted in wide reaches. By these means the motion of bars downstream was to be prevented, and the river currents given such directions as to maintain the proposed depth over the bars, which for the portion of the river between Cairo and St. Louis was to be 8 ft. and below Cairo 10 ft. These projects contemplate no violent change in the regimen of the river, which is allowed to follow the sinuous course to which it naturally tends, with deep pools in the bends, and on the crossings bars which rise and fall with variations in gage height.

There is an ample water supply for a channel 14 ft. deep and 500 ft. wide from St. Louis to the Gulf at the lowest stages of the river, and on existing slopes, but great care will have to be exercised in making so great a contraction as would be necessary to confine the river to a 14-ft. channel. As a river is reduced in width and increased in depth a much smaller proportion of the discharge comes in contact with the river bed, and the velocity of the river currents rapidly increase. A condition soon obtains where instead of the bar being alternately scoured out and filled up as the river discharge decreases and increases, there is a constant scour. The dam which nature has placed between the pools is then destroyed. The material which formed this dam is washed into the lower pool, tending to raise it, while the upper pool tends to fall to the same level.

If these dams between pools were destroyed for long distances, as between St. Louis and Cairo, a very serious change in the regimen of the river would result. Its slope would be diminished, immense quantities of material would be washed down into the lower river, adding enormously to its bars, filling up its pools, raising its flood levels, and making necessary expensive additions to its levee system; and falls or rapids might be created at the Chain of Rocks above St. Louis, which would be destructive to the navigation of this portion of the river.

A comparison of discharge measurements, taken at St. Louis in 1880 and 1881, with those taken in recent years, 1900 to 1904, indicates a tendency towards the lowering of the river bed at St. Louis under the existing project. If the river is further contracted so as to obtain and maintain a depth of 14 ft. without dredging, it will be necessary in some manner to limit the process of bar deepening described above.

For this purpose a project has been prepared which proposes to remove local irregularities in the regimen of the river from St. Louis to Cairo. About Commerce the river is to be given a uniform minimum width of 500 ft. at a depth of 14 ft. below a zero stage, a width of 1,700 ft. at the zero stage, and 3,000 ft. at the bank-full stage for most of its length. The bars are to be scoured or dredged to the required depth and the pools are to be filled or allowed to fill so as to produce as

nearly as practicable a uniform slope of 0.55 ft. to the mile, which is the present average slope from St. Louis to Commerce. Below Commerce the bottom width is to be 500 ft., the width at a zero stage 1,500 ft., and at a bank-full stage 2,750 ft., with a uniform slope of 0.76 ft. to the mile, which is the present average low-water slope between Commerce and Cairo.

To prevent a further deepening of the river, it is proposed to construct submerged dams of brush and rock, whose crests will conform to the section it is desired to give the river below the zero stage, these dams to be spaced at distances varying from ¾ to 5 miles. The river is to be contracted above low water by permeable and solid wing dams as in the existing project and caving banks are to be revetted; but more care is to be exercised in producing uniform slopes in the river bed for the purpose of directing in the proposed channel at all stages, the portion of the river current having the maximum velocity.

By this method of improvement considerable dredging will be necessary during the first few years of work; but the amount of dredging will rapidly diminish as the improvement nears completion. The estimated cost of the work is $53,216,480 including maintenance during construction. After completion the annual cost of maintenance is estimated at $500,000. These estimates are based upon over 25 years' practical experience with partial regulation in the St. Louis Engineer District.

CANALIZATION WITH MOVABLE DAMS.—In further compliance with the resolution of Congress the Board has considered a plan for obtaining at all seasons of the year 14 ft. in the river between St. Louis and Cairo by means of locks and dams similar to those projected and in use on the Ohio River. The locks have interior dimensions of 600 × 80 ft., conforming to the dimensions of the locks on the 14-ft. waterway proposed from Chicago to St. Louis. The movable dams have navigable passes closed by Chanoine wickets having a length of 19.5 ft. These wickets are 1 ft. 8 ins. longer than those used on the Ohio River, which provide for only 9 ft. navigable channel, and are therefore larger than any that have heretofore been built for river canalization. The regulating weirs constituting the remainder of the dam will also be closed by Chanoine wickets of varying lengths.

The estimated first cost of this project is about $25,000,000, and of its maintenance about $400,000 per year. These estimates are based upon many years' practical experience with similar dams on the Ohio River.

CANALIZATION WITH FIXED DAMS.—The Board has had an extensive system of borings made throughout the valley from St. Louis to Cairo, and has found but one locality where satisfactory foundations for masonry dams exist except at depths so great as to preclude economic construction. Between Thebes and Commerce a limestone foundation underlies the river within reasonable depth, and a high masonry dam could be constructed that would materially reduce the slopes that exist in the river above as far as St. Louis.

When first constructed such a dam would give the desired 14-ft. waterway; but as the reduction in slopes and increase in area of cross section of the river would necessarily diminish the velocity of discharge, there would be a deposit of sediment which would rapidly fill the reservoir thus created. The existing slopes have resulted from natural laws which would remain in operation after the dam was constructed, and the ultimate effect of building a solid masonry dam at this locality would be to raise the entire bed of the river above. Such a dam would moreover largely increase the height of floods, and the cost of the land it would be necessary to condemn would add enormously to the cost of the work.

But if instead of a solid masonry dam which allowed water to flow only over its crest, there were constructed a dam with large openings through it, controlled by suitable valves, through which the entire river discharge could pass even at extreme floods, a large amount of the sediment instead of being deposited above the dam would flow through it. There would however still be a tendency for the river bed above to rise, but at a greatly reduced rate.

The amount of dredging that would be required to maintain a 14-ft. waterway under this project would be no greater than with the system of movable dams above described, and this project would possess the great advantage that it would develop water-power which could be utilized for industrial purposes.

The Board has investigated in a general way the possibilities of such a project. It has ascertained that such a dam would flood 30 towns and villages in the Mississippi Valley, over 240,000 acres of farming land and over 220 miles of railroad. It is believed that the mere cost of this property would exceed the total cost of the system of movable dams described above. Therefore no project nor estimates for such a dam have been submitted.

LATERAL CANALS.—The Board has also had estimates prepared for the construction of a lateral canal on the Illinois side of the river, from the terminus of the proposed Alton-St. Louis canal to Cairo. The canal is planned to have a bottom width of 160 ft. and slopes of 1 vertical on 2 horizontal. The locks are to be constructed of concrete and to have clear interior dimensions of 80 ft. × 600 ft. For a single continuous canal the first cost of the work is estimated at about $102,000,000, and the annual cost of maintenance at about $600,000. A large item in the cost of such continuous canal consists of the land damages and cost of bridges in the vicinity of East St. Louis, and the cost of the very heavy excavation on the Illinois side through bluffs above and below Chester and also through the gorge of the river between Thebes and Commerce, and the cost of an aqueduct bridge across the Kaskaskia River. By crossing the river to avoid the heavy excavation near Chester and the aqueduct over the Kaskaskia and placing a short section of the canal on the Missouri side of the river the first cost of the above canal project can be reduced to about $76,600,000. These two projects have not been worked out in detail because the costs were considered excessive.

By using a portion of river near East St. Louis, another portion opposite the Kaskaskia and Chester, and a third from near Cape Girardeau to Commerce, the cost can be much further reduced. Careful estimates of cost have been made for such a combined canal and river route with three canal sections connected with three river sections in pools held up by dams, the canals being located entirely on the Illinois side of the river.

According to this latter project there are 18.1 miles open river from the Eads Bridge to the Meramec River, thence a canal 39.8 miles in length to the Kaskaskia River, thence open river navigation for 16.1 miles to the foot of Crains Island, thence a canal 45.2 miles to head of Devils Island, thence 18.9 miles of open river navigation to Commerce, thence 15.5 miles of canal to Pond Lily Crossing, and thence by river to mouth of Ohio River 7.7 miles, the river navigation to be secured by three movable dams. The estimated first cost is about $36,000,000, and the annual cost of maintenance about $450,000. The estimates conform to the same general conditions as to construction and prices as were adopted for the similar proposed canal from Alton, Ill., to St. Louis, reported upon in 1905.

RESERVOIRS.—The theory of the method of improvement of a river by reservoirs is that the flood waters can be impounded in large quantities at the headwaters of the streams in such way as to reduce flood heights in the lower reaches of the same streams; and that these waters, stored until the low water season, can then be so discharged as to raise the low water surface of the river and increase the navigable depths. This method of improvement was introduced many years ago on the Upper Mississippi River above St. Paul, and five reservoirs have been built with an area of 480 sq. miles, and a storage capacity of over 93,000,000,000 cu. ft.

More reservoirs and more storage capacity were at first recommended, but so far Congress has not considered favorably the extension of the system. This system of artificial reservoirs is one of the largest in the world so far constructed for regulating river discharge for navigation purposes, and yet the increase in height thereby obtained at St. Paul during the low water period, about 90 days, averages only 14 ins.; the results so far noted ranging from 40 ins. maximum increase in height in 1900 to 5 ins. minimum increase in 1903. The river at St. Paul has a low water width of only 400 ft. and an average low water discharge during the season of navigation of but 2,500 cu. ft. per sec. The effect of the reservoir system diminishes as the river becomes wider, and finally disappears at the head of Lake Pepin, 51 miles below St. Paul.

In order to obtain the effects above named as reported at St. Paul, it has been found necessary to commence the discharge of water from the reservoirs considerably in advance of the low water stage at St. Paul, owing to the length of time that is necessary for the water to traverse the intervening river. After the discharge has been commenced at Lake Winnibigoshish, its effect is not specially felt at Lake Pokegama, the distributing reservoir, 63 miles further downstream, until after an interval of 21 days at low water, nor at St. Paul, 351 miles below Lake Pokegama, until after a further interval of ten days. In order to use this reservoir system for the benefit of the improvement of the river below St. Louis, it would be necessary to commence the discharge at the reservoirs at least two months before it was needed at St. Louis; and a still greater interval would be necessary for the benefit of improvement of the river below Cairo. Experience does not justify such long forecasts, and the service of the reservoirs would necessarily have to be based on general annual averages, an unreliable and unsatisfactory basis. There have been occasions in the past when unexpected floods in the summer time would have been aggravated by any large additions from upper reservoirs. In order that reservoirs may give reliable service, they should be so located as to diminish time of water flow to a minimum. In the case under consideration this would necessitate the location of the reservoirs in the lower valleys of the tributaries, where the land is of great value; and such location would add enormously to the cost of the reservoir system, even if it were practicable.

While this method of improvement has been successful on the Upper Mississippi near St. Paul to the limited extent above described, a further extension of its application to a river of the dimensions of the Mississippi below St. Louis is attended with much difficulties, and must necessarily give results much less beneficial.

Theoretically, a water supply is available above St. Louis, sufficient to increase largely the low water discharge of the Mississippi River at and below St. Louis. Special investigations recently made as to the maximum possibilities of the Mississippi River reservoir systems above the mouth of the Missouri River, with special view to water-power development by private parties, gave results shown in Appendix No. 8. It there appears that the maximum reservoir facilities of the river, including 10,000 cu. ft. per sec. that may come through the Chicago Sanitary Canal and Illinois River as recommended by the International Waterways Commission amount to about 69,500 cu. ft. per second for 90 days, equal to about 540 billion cu. ft. total storage.

Moreover, a dam could be constructed across the mouth of the Illinois River, with a height of only 27 ft. above low water, to produce a reservoir over 227 miles in length in a valley in which over 400,000 acres have been subject to overflow in the past during extreme floods.

Investigations by the Corps of Engineers have shown that such reservoir systems in the Allegheny River Basin would cost about $415 per million cubic feet total storage; in the Monongahela River Basin, about $416; and in the Kanawha River Basin, about $370. While the reservoirs at the headwaters of the Mississippi River have been constructed at low cost, the location of reservoirs at such points as would promise any reliable supply of water to the lower river would have to be under conditions as to cost similar to those just named.

In the Upper Mississippi River near St. Paul, where the river banks and bed are of comparatively solid material, an increase of 14 ins., or even 40 ins., in gage heights, does not produce sufficient current to cause serious motion in the gravel bars which there largely form the bed of the river, so that the increase in depth produced near St. Paul is a direct function of the river discharge. But in the Mississippi River below St. Louis, any increase of discharge accelerates the currents and sets in motion the light sands which constitute its bed, to the injury of the channel, as verified by a careful examination of a great number of reliable soundings made in the Mississippi River below St. Louis. The results of these examinations indicate between St. Louis and Cairo a rise of the river bed on the controlling bars equal to about one-half the rise of water stage until at least 14 ft. depths are reached which corresponds to a 22-ft. stage on the St. Louis gage. Such rise of the river bed indicates that the maximum of 540 billion cubic feet total storage which might be obtained by reservoirs in the Mississippi River Basin from the Illinois River upward, could not maintain throughout the year more than 8 ft. available depth between St. Louis and Cairo, the increased discharge from the reservoirs tending to create a wider channel rather than a deeper one, and being useful, therefore, only as an auxiliary to other methods of improvement. To hold the water stage at St. Louis at 22 ft., the stage corresponding to a controlling depth of 14 ft. between St. Louis and Cairo, would require over 5,000 billion cu. ft. annual storage, or about ten times what has yet been found possible.

COMBINATION OF METHODS.—The Board has considered the securing and maintaining of a channel of 14 ft. depth between St. Louis and Cairo by completing the project of 1881 for 8 ft. depth and then securing the additional 6 ft. depth by dredging instead of by further contraction. The estimated cost of completing the project is $21,000,000 and the cost of dredging plant for obtaining the additional 6 ft. is estimated by the Board at $3,600,000, and the cost of maintaining the improved channel at $1,500,000 per year.

Considering the stretch of the river below Cairo, a project has been prepared to secure permanence of bank lines and channels during progress of the dredging previously estimated, by which such dredging will be reduced. This work has been estimated to cost $95,000,000 with an annual maintenance charge of 5% of the amount expended. The estimate for dredging is $9,000,000 for plant and $2,100,000 annually for operation.

These estimates are based upon many years' experience of the Mississippi River Commission in this part of the river; but the maintenance of the bank protection so far done has included that of much experimental work which has necessarily required excessive repair, and it is believed by the Board that in the comprehensive plan proposed the maintenance charge should be largely reduced; moreover the cost of dredging will materially diminish as the bank protection progresses, and the total annual cost of maintenance should not exceed $5,000,000, when the bank protection is complete.

DISCUSSION AND CONCLUSIONS.—The estimates of cost accompanying the several projects considered by the Board have been prepared with great care and

based upon the best data available. In works of such magnitude of this nature, however, it is not possible to make estimates which can be fairly considered as more than approximations of the most general character.

As already stated, the Mississippi River has in the regular boat channel at low water an average depth through pools and across bars of about 18 ft. from St. Louis to Cairo, thence 31 ft. to Memphis, thence 37 ft. to Vicksburg, thence 48 ft. to Red River Landing and over 80 ft. below Red River Landing. But the depths which control navigation, are the depths over the worst bars; and if all improvements should be stopped so as to allow the river to revert to a natural condition, such controlling depths would be at low water about 4.5 ft. in the reach from St. Louis to Cairo, and about 6.5 ft. in the reach from Cairo to Red River.

The quickest and most economical method of deepening any bar is by dredging, until the amount of excavation becomes excessive. The four dredges now in service between St. Louis and Cairo, have for many years, through the entire season of navigation, except occasionally for a few days, successfully maintained a good channel of at least 8 ft. depth throughout the entire reach. The nine dredges in service below Cairo have for many years maintained a good channel of at least 9 ft. depth under similar conditions. The Board considers that these controlling depths can, with reasonable certainty be increased up to 12, and possibly 14 ft., at the lowest stages of water, throughout the reach above Cairo and to 14 ft. below Cairo, in the manner described under the head of dredging. But any improvement obtained by dredging alone must be recognized as temporary in its results.

In order to secure permanence of channel in open river navigation it must be protected by works of regularization; after which the annual dredging may be reduced in amount and restricted mainly to emergencies. The existing project of 1881, from St. Louis to Cairo, is one of river regularization, well adapted to this part of the river. The Board considers that this 1881 project, if completed as originally proposed, should permanently increase the controlling depth at low water to 8 ft., and that a further increase to 14 ft. can be secured by dredging. But if permanent depths greater than 8 ft. at low water are to be obtained, the bed of the river as well as its banks must be protected.

The Board considers that the method of improving the open river below St. Louis by regularization is feasible, in harmony with all past successful river improvement in the United States and Europe, can be applied first to the worst sections of the river, and will give the best permanent results to navigation attainable in the river.

The Board does not recommend slackwater navigation obtained by the use of dams, either fixed or movable, for the river below St. Louis.

The Board is of the opinion that 14 ft. depth can be obtained with certainty by a lateral canal; but a continuous canal from St. Louis to Cairo is considered altogether too expensive, a river crossing would be of doubtful permanence, and the project making partial use of the river is considered open to the objections applying to improvement by dams; the same objections apply more forcibly to a canal below Cairo.

The Board considers the method of improvement by reservoirs, for reasons stated under that heading, to be at the present time impracticable. There is no case on record known to the Board where such method adopted solely or even principally for purposes of navigation, has given results commensurate with the expenditure.

As stated later, in the discussion of the desirability of a 14-ft. waterway, the Board is of the opinion that the proposed waterway is adapted to neither lake nor ocean vessels, and that if constructed it would be followed by an immediate demand for a channel of greater depth. In case it should become necessary to obtain increased depth, canals, dams, and complete regularization works would have to be modified under great difficulties and at great cost. Canal locks would have to be rebuilt and canal trunks deepened and partially relocated. Movable dam wickets, already larger than any yet built would become more difficult of manipulation, and their operation perhaps impracticable, and the substructure would have to be rebuilt. Cross sills of complete regularization work would have to be taken out and rebuilt at lower levels in the channel way or extensively raised outside the channel way. In each case the difficulty and cost of securing the increased depth would, of course, be much greater than if the extra depth were obtained at the time of first construction. The method of improvement by partial regularization combined with dredging, will be the method least seriously affected by future changes in depth, breadth and location of the navigable channel.

After considering the advantages and defects of all the methods of improvement proposed, the Board concludes that the most practicable method of obtaining and maintaining a navigable channel of 14 ft. depth from St. Louis to Cairo is by the completion of the project of 1881 for partial regularization in such way as to secure a permanent controlling depth of 8 ft., and then to rely upon dredging for securing and maintaining any further increase of depths; the side contraction works to be so located as to be in harmony with further works of improvement by complete regularization, if in future such works be found necessary and advisable.

The Board rejects, as opposed to all reason, all propositions requiring the abandonment of the already good open river navigation or the substitution of a lateral canal for any part of the river below Cairo. The surveys of the Board and Mississippi River Commission indicate that nearly one billion cubic yards of material annually fall into the river from caving banks, an amount greatly in excess of the sediment brought into the river by all its tributaries. While but a comparatively small percentage of this material is deposited on the bars, the prevention of such an enormous mass of silt from entering the river must eventually reduce the amount of dredging required. No permanence of channel depth or of location of channels, levees, wharves, landing places or other terminal facilities can be expected until after the banks have been effectively protected. Dredging and bank protection, with the addition at certain localities of contraction works, as an auxiliary, will achieve these results which cannot be obtained by dredging alone, and is therefore in the opinion of the Board the most practicable method of improvement.

The estimated cost of this work above Cairo is $24,600,000, and $1,500,000 per annum for maintenance; and below Cairo $104,000,000, and not exceeding $5,000,000 per annum for maintenance.

### Present and Prospective Commerce.

The Mississippi River Commission collects and reports annually the commerce of the river below St. Louis. The Bureau of Statistics of the Department of Commerce and Labor makes similar reports of the entire river and tributaries. These reports are considered by the Board the most reliable ones obtainable. During the calendar year 1908, an actual shipment of about 1,300,000 tons of coal came out of the Ohio River, of which about 180,000 tons went up the Mississippi to St. Louis. Outside of the Ohio River coal, the average movement of water freight during the year at all points on the river between St. Louis and New Orleans was about 400,000 tons downstream and 300,000 tons upstream. This commerce of the river has been rapidly diminishing in recent years. The total river tonnage of St. Louis was in 1886, 1,332,885 tons; in 1896, 1,244,175 tons; in 1906, 416,855 tons; and in 1908, 365,920 tons, of which not over 49,530 tons was with towns on the Mississippi below Cairo. The entire commerce of the Mississippi River system, including all tributaries except the Ohio, was reported in 1889 as 12,492,535 tons; while in 1906, it was only 4,304,288 tons; showing a loss of two-thirds. The 1908 river commerce of the system so far as reported, shows a slight decrease as compared with that of 1906, except as to a few of the minor tributaries.

Although the Board has sought to obtain from the commercial organization along the route from Chicago to New Orleans, information as to the prospective commerce which requires a 14-ft. navigation, it has received very little definite information in that direction. No actual large future development of commerce is yet in sight. The demand for increased depth appears to be more conjectural than real, and to be based mainly upon the idea that a deep water channel will of itself cause development of commerce, and that the Federal Government should consequently provide depth considerably in excess of what is actually needed, on the ground that business follows facilities, and that the rivers and harbors doing the largest business and doing it most efficiently are those that have kept their facilities ahead of actual requirements.

The Chicago public (See 1909 reports of the Chicago Harbor Commission) claims that Chicago is destined to become one of the greatest commercial and industrial centers of the United States, and that with its free access to the Great Lakes, and a deep waterway to the Gulf, it will be able to send to South America and to the Pacific Ocean via the Panama Canal, large quantities of manufactured articles (especially those of iron and steel) from factories to be established at the south end of Lake Michigan. They claim also that the existence of a 14-ft. depth outlet from the Great Lakes to the Ocean through Canada demands a similar outlet through the United States, and that this should be by way of the Mississippi valley; and further, that the opening of a 14-ft. route, even to empty boats, would allow a transfer of lake boats, now idle through the winter, to southern waters, and so cheapen and develop commerce between Gulf ports.

The Upper Mississippi public claims that a deep waterway from the mouth of the Illinois River to the Gulf, will encourage the shipment down the Mississippi River of ores and flour from Minnesota and Iowa, and coal from Illinois, along with miscellaneous manufactured goods. The Missouri River valley public, together with the people of the States of the Great Plains, claim that a deep waterway below St. Louis will, after the Missouri River has been further improved, facilitate the shipment of farm products, oil and minerals, from the Western States to the Gulf.

Indiana has coal which it hopes to deliver to a southern market.

The people of the States bordering on the Lower Mississippi, appear to claim that a deep waterway will facilitate the present shipments of coal, steel, and manufactured products from the Ohio River down the Mississippi, and will also encourage an upstream navigation, at least as far as St. Louis, of ore and other minerals from Alabama and the neighboring States, as well as cotton, tobacco, sugar, agricultural implements, fertilizers, and foreign imports; some parties assuming that cotton will be sent for manufacture to northern mills, rather than to mills to be established later in the South; also that the Mississippi River valley (including the Ohio and Missouri) rich in natural resources, still sparsely settled, and but little developed compared with Atlantic States, is susceptible of rapid and great further development with influx of population and money.

The St. Louis Lakes-to-the-Gulf Deep Waterway Association, and the St. Louis Merchants Exchange (See letters in Appendix No. 20) claim that a large amount of the commerce now carried by rail parallel to the Lakes-to-the-Gulf route would be transferred to a deepened river, and that this transfer would leave the railroads free to take up an equal quantity of freight which they are now unable to handle because of restricted transportation facilities; and also that a deeper waterway between St. Louis and Cairo would bring more coking coal from the Ohio to St. Louis.

The prospect of an early completion of the Panama Canal also appears to be a prominent argument for deeper draft; the idea being generally that this canal will put the Mississippi valley in such easy connection with South America and the Pacific as to cause a great development of export trade, a large part of which Chicago and St. Louis hope and expect to control.

### Desirability of a Fourteen-Foot Waterway.

If a 14-ft. waterway from Chicago to the Gulf would enable vessels of the Great Lakes to carry freight to cities and towns of the Mississippi valley and the Gulf of Mexico, and enable ocean commerce to be carried up the river without breaking bulk at New Orleans, both general and local commerce would be greatly benefited.

The Board on the survey of a 14-ft. waterway from Lockport to St. Louis invited attention to the fact that two-thirds of the tonnage of vessels entering the Chicago River were of so great a draft that they would be unable to utilize a 14-ft. waterway if constructed. This Board has further investigated this subject.

During the season of 1907, of a freight tonnage of 58,217,214 tons which passed through the canals at the Sault Ste. Marie, only 800,000 tons were in vessels of a registered draft of 14 ft. or less, 10,400,000 tons were in vessels of a registered draft of from 14 ft. to 19 ft., and 47,000,000 tons in vessels of 19 ft. registered draft or over, of which 33,000,000 tons were carried in vessels capable of being loaded to depths exceeding 21 ft.

When the Illinois Legislature in 1889 advocated a 14-ft. waterway from Chicago to the Gulf, Canada could reach the upper lakes by the Welland Canal, 14 ft. deep, and the navigation of the Great Lakes was generally in vessels which might possibly utilize such a channel, but the rapid increase in depths of the harbors and channels of the Great Lakes has radically changed conditions. Since 1902, bulk freighters have been launched at the various shipyards of the Great Lakes having an aggregate tonnage of over 1,500,000 tons, and capable of carrying in a season on the Great Lakes over 30,000,000 tons of freight. On a 14-ft. waterway these vessels could barely carry the necessary fuel supply required for a trip of about 1,600 miles from Chicago to the Gulf.

"At the present time the value to commerce of a 13-ft. harbor on the Great Lakes is entirely incommensurate with the cost of maintenance. To be accessible to even the smaller available vessels, a harbor should have a depth of at least 16 ft."*

During the past twenty years the channels to harbors along the Atlantic and Gulf coasts have been excavated to even greater depths than those of the Great Lakes, and but a comparatively small portion of the ocean-borne commerce of the United States could utilize a 14-ft. waterway. Nor are ocean and lake vessels as economic a means of transporting products on rivers and canals as barge tows. Due to the necessity of building the ocean vessel of sufficient strength to resist violent storms, her cost in the United States is about $71 for each ton of freight carried. On the Great Lakes vessels are exposed to storms of less violence, and the cost is about $41.50 per ton of freight carried. A Mississippi River steamboat and ten barges capable of transporting 10,000 tons of freight on an 8½-ft. draft can be built for about $12 per ton of freight carried.

A modern lake freighter moreover is poorly constructed for navigating a tortuous river with a swift current. The ratio of length to beam is too great and the rudder power insufficient. Such vessels have been developed for a special purpose, and while affording "a most economic method of transporting freight on the Great

*See Report of Chief of Engineers, 1908, p. 1905.

Lakes, would be a failure if employed in either ocean or river navigation.

The Board is of the opinion that a 14-ft. waterway is suitable for neither existing lake nor ocean vessels, that freight originating on Lake or Gulf will require transhipment to vessels adapted to its navigation, and that its principal value will be to provide for commerce that originates along its banks, or those of its tributaries, until the introduction of some form of vessel adapted to all conditions of navigation. When such a vessel shall be designed, there will be an immediate demand for a channel of greater depth than 14 ft.

### Whether Other Plans of Improvement Can Be Devised By Which the Probable Demands of Traffic, Present and Prospective, Can Be Adequately Met.

It is the opinion of the Board that the present demands of traffic are adequately met by the existing projects for improving the river, and that only the creation of a commerce, which must originate from sources that do not at present ship by river, would justify the great cost of a 14-ft. waterway. The present condition of this waterway appears to have been generally overlooked, and few people who have not specially examined it realize what has already been accomplished.

In the Mississippi River as at present improved, there usually exists, and has existed since 1901, a good navigable channel of at least 8 ft. depth over at least 200 ft. width for the 182 miles of river between St. Louis and the mouth of the Ohio River; and of at least 9 ft. depth and 250 ft. width for the 790 miles from the mouth of the Ohio River to just below the mouth of the Red River; and of at least 30 ft. depth and several hundred feet width for the remaining 320 miles to the Gulf.

During the low water season when the shoaling of some crossings took place suddenly through rapid fluctuations in river stage at a time when the dredging plant was engaged elsewhere, minor deficiencies in channel depths for short periods have occasionally occurred. In the winter season navigation has been interfered with by ice for periods aggregating, above Cairo, only about one month per year, and from Cairo down to Memphis only a few weeks in occasional years. A good channel of at least 14 ft. depth can usually be found every year between St. Louis and Cairo during from one to two months, and between Cairo and the Gulf during from five to eight months.

The existing improved waterway of the Mississippi River below St. Louis fully equals, and over the greater part of its extent far excels, in depth and duration of unobstructed use, the existing river systems of Europe, where the non-tidal sections are usually given depths of only 3 to 9 ft., 9 ft. being exceptional and 10.5 ft. a maximum.

The immense commerce of the Rhine could be carried more readily and cheaply on the Mississippi to-day, than on the Rhine, if such commerce were available for the transportation by water, and demanded such transportation.

The decline in the commerce of the river has not arisen from its lack of navigability but from the reduction in amount of material available for shipment. When a large proportion of the grain was raised east of the river, St. Louis was a natural outlet to grain and other farm products seeking Gulf ports, and a flourishing commerce existed between St. Louis and New Orleans by water; but at the present day 70% of the wheat and 50% of the corn of the country are raised west of the Mississippi. Kansas City, Omaha, and Minneapolis have become the great grain centers. Grain and other farm products seeking Gulf ports find a rail line from Kansas City to Galveston which is cheaper than a rail transportation to St. Louis increased by the cost of river transportation from St. Louis to New Orleans, and the only grain that can move down the river is that locally consumed along its banks.

The Mississippi River from St. Louis to New Orleans flows through a sparsely settled country. According to the census of 1900 there was between these points but one town on its banks of over 15,000 inhabitants (Memphis), and but six others with a population exceeding 5,000. The manufacturing industries, or demands for manufactured articles, in so thinly settled a region are slight. There are no mineral deposits along its banks, and its agricultural products are principally corn, cotton, sugar cane and rice. The alluvial soil of the Mississippi valley with the heavy rainfall of this region, renders its common roads almost impassable, so that a long haul to or from the river bank becomes very expensive, and confines the commerce of the river to those products raised or expended on its immediate banks.

While the Panama Canal may have a tendency to divert more commerce to a northerly and a southerly direction than heretofore, it will be principally in high grade articles, and not in crude products which experience has shown are adapted to water transportation.

Of the commerce which passed through the canal at Sault Ste. Marie in 1907, 97½% consisted of iron, coal, lumber and grain. In a thickly settled community, such as is found along the Hudson River, a heavy waterborne commerce may develop in building material, such as stone, brick, lime and cement; but with the small population in the Mississippi valley below St. Louis, the transportation of these items would be insignificant. It is considered probable that if a deeper waterway existed from Chicago to the Gulf, the principal additions to existing commerce would be coal from Illinois moving toward New Orleans, and lumber from the South towards Chicago.

As was shown in a report on a survey of the Ohio River (House of Representatives Document No. 492, 60th Congress, 1st Session), products can be cheaply transported on barges having a draft of 8½ ft. It has been estimated that coal can be shipped in barges from Pittsburg to New Orleans on a 9-ft. canalized river at 0.376 of a mill per ton mile, while the estimated cost of transportation on the ocean in vessels of 21 ft. draft is 0.35 of a mill per ton-mile.

Finished products seek rail transportation, and the only effect of navigable waterways upon their transportation is a possible reduction or control of freight rates. The existing improvement of the Mississippi River has had a marked effect on freight rates between St. Louis and New Orleans, reducing them nearly to those between St. Louis and New York. These latter rates have resulted from the influence of the Great Lakes and the Erie Canal on the competing Chicago rates, similarly the influence of the Mississippi River on southern rates from St. Louis affects those from Chicago south, and but little reduction can be expected from a further deepening of the river.

The Board is of the opinion that the development of the waterways of the Mississippi valley into a harmonious system will be of immense value to the country, but the Ohio valley has been and probably will continue to be the line of greatest commerce; and the probable demands of the commerce, present and prospective, for many years to come, can be adequately met by a channel of 9 ft. depth between Chicago and Cairo, of dimensions similar to those proposed for the Ohio River, a project which requires no violent change in existing methods of improvement, and which will not necessitate the diversion from the Great Lakes of a water supply which will injuriously affect the channels through which its immense commerce passes.

### Specific Questions of Congress.

So far as known to the Board, the greatest depth so far sought by regulation in a non-tidal river is three meters (9.8 ft.) to which depth the lower Rhine is at present being improved. The Board is of the opinion that the Mississippi River from St. Louis to Cairo is susceptible of improvement to the same depth; but to obtain a greater increase in depth by regulation works alone, is problematical and without precedent.

The Board reports on the specific questions contained in the Act of March 2, 1907, as follows:

First: It is practicable to produce between St. Louis and Cairo at low water by means of regulation works a channel of at least 10 ft. depth.

Second: A depth of at least 14 ft. will obtain in such regulated channel at the average stage of water for the year, 12.6 ft. on the St. Louis gage.

Third: 14 ft. depth of water will obtain in such regulated channel for at least an average of 163 days annually.

Fourth: The increase of depth which will be obtained by an added volume of water over the natural flow in such regulated channel will be much less than the increase in water stages, and between St. Louis and Cairo this increase in depth at low water stages will be not more than 6 ins. for 10,000 cu. ft. per second, nor more than 8 ins. for 14,000 cu. ft. per second; while at high water stages the increase will be less. Below Cairo this increase in depth will be much reduced for low water stages and will be inappreciable at high water stages.

With the banks revetted, so that the supply of material to the bars is reduced to a minimum, the height which bars will attain during floods should materially diminish. On the improved Rhine River the ratio of the rise of bar to the increase in gage height is reported as 1 to 3. What the ratio would be on an improved Mississippi must remain conjectural until actually tested.

Fifth: It will not be practicable to produce at all seasons of the year a depth of 14 ft. in such regulated channel by the aid of locks and dams similar to those projected and in use on the Ohio River improvement, without extensive annual dredging.

Sixth: Regarding the water power to be created and the lands to be drained in the portion of the Mississippi River which the Act of March 2, 1907, directed to be surveyed and in the proposed waterway from Lockport, Ill., to St. Louis, Mo., heretofore surveyed, the Board reports, as follows:

This Board submits no project for creating water power, nor does it propose to drain any lands on the portion of the river directed to be surveyed.

The Board which submitted a report in 1905 upon a waterway from Lockport, Ill., to St. Louis, Mo., recognized the riparian rights of property holders and proposed a channel which would interfere with those rights as little as practicable, and its plans did not contemplate the drainage of any lands in the Illinois valley. On the contrary the Board invited attention to the fact that the diversion of 10,000 cubic feet per second from Lake Michigan into the Illinois River would cause extensive damage to the lands subject to overflow, for which the Sanitary District of Chicago would be liable; and its estimates appear to have been prepared on the assumption that this district was to settle such claims for damages. The Board evidently considered the diversion of more than 10,000 cu. ft. per sec. as unnecessary and undesirable. It further stated that with the limited discharge of about 4,200 cu. ft. per sec., which was all that had been authorized prior to 1905, 224 suits had already been brought against the trustees of the District, the claims aggregating $[illegible],180.

A large water power can be developed by the diversion of either 10,000 or 14,000 cu. ft. of water per sec. from Lake Michigan into the Illinois River, but its utilization as at present proposed by the State of Illinois will require radical changes from the project contained in the 1905 Report, and will involve serious legal difficulties if the Government of the United States attempts to conserve such power.

An available horsepower, aggregating 173,0[illegible] between Lockport and Utica with a discharge of 14,000 cu. ft. per second, is to be developed under a project submitted by the Internal Improvement Commission of Illinois, Feb. 27, 1907, and subsequently indorsed by the Governor and the people of the state; but this project is a most radical departure from the project of 1905, and contemplates a lowering of the level of the river below Utica of about 10 ft. The nine locks of the Board's project are to be replaced by five with a corresponding increase in the heights of dams, and while the Board proposed to disturb the flood conditions as little as possible, the state asserts that "these should be disturbed as much as possible," and apparently assumes that the United States will accept responsibility for damages caused by overflow in the Illinois Valley. The proposed lowering of the river bed of about 10 ft. below Utica will render necessary instead of the excavation of the 27,535,805 cu. yds. of material, estimated by the Board as necessary between Utica and Grafton, at first the excavation of some 190,000,000 cu. yds. of material ultimately to be increased to between 300,000,000 and 400,000,000.

It is only by some modified project that the lands in Illinois valley can be drained by gravity, but the Board can suggest no method by which the cost of the improvement can be defrayed, in whole or in part, by the land benefited. On the contrary, it is the opinion that if the United States accepts such a proposition, it might be compelled to pay for the lands on which it would have to deposit this immense mass of dredged material, and to pay also for supposed damages from floods.

Under such circumstances, the Board considers that the question of land reclamation and of the conservation of the same, between Chicago and the mouth of the Illinois River, should be left entirely to the state of Illinois, that the Federal Government should neither require nor accept from the state or the Sanitary District any payment for any increase in valuation of such lands; and that it should in no way relieve the state or the Sanitary District from the responsibility for overflow of lands by the Lake Michigan water diversion; the cost of flowage damages being a proper charge against the income from the available water powers developed by such water diversion.

The sites available for power purposes on the Des Plaines and Illinois Rivers are now owned by the state of Illinois, the Sanitary District of Chicago, large corporations and private individuals; and their titles to power rights will have to be extinguished before the Government can intervene to conserve the power it is proposed to develop. By modifications in the project submitted by the former Board that will be in harmony with its report, this Board is of the opinion that 100,000 HP. can be developed by the diversion of 10,000 cu. ft. per second.

The experience of the general Government in renting power rights has not heretofore been such as to justify the Board in assigning in general a fixed value per HP. year for such rights. Water powers are reported to have been leased by the Federal Government at rates as low as about $0.65 per HP. year by the Forestry Bureau, for the first five years, at the Cascade Mountains, and $0.53 to $2.65 by the War Department on the Muskingum River, Ohio; these low rates being accepted because they were the best offered.

In other cases, as on the White River, Arkansas, where water-power was available for lease and coal was sold at about $3.75 per ton in carload lots, the best offers (not accepted) have been from $0.50 to $1.00 per gross HP. year. On the other hand, where water-power is in great demand, and can be sold in small quantities, a net HP. at the turbines is understood to have brought as high as $75 per year.

Water-power is particularly valuable near large commercial centers like Chicago. The Sanitary District of Chicago and the state of Illinois, in presenting the matter to the public for vote on the question of a $20,000,-

000 bond issue, have valued this water-power between Chicago and the Illinois River as worth at a reasonable valuation [illegible] per HP. year; these figures being indorsed tentatively by the Sanitary District of Chicago, but by the Illinois State Internal Improvement Association, and by the Governor.

Under these circumstances it seems proper that the Federal Government should assume, in its dealings with the Sanitary District of Chicago and the state of Illinois, the principal beneficiaries, that the net HP. developed by 10,000 cu. ft. per second diverted from Lake Michigan should produce a revenue of $2,500,000 per year.

The Board considers that the property owners along the canal and Illinois River are equitably entitled to the water-power due to the natural flow alone of the Des Plaines and Illinois Rivers, and that any power which results from an added flow diverted from Lake Michigan belongs to the people of the United States and Canada.

The Board is of the opinion that the United States will receive adequate compensation for the water-power created by the diversion of the water of Lake Michigan now authorized by the U. S. War Department to the Sanitary District of Chicago, and the latter will also be adequately compensated for its expenditures upon canal and water-power, by an agreement between the United States and the Sanitary District under which the canal shall be opened to free navigation and so maintained by the District, said District to enjoy free use of the power so created, until the aggregate value of said power shall equal the cost of canal and power construction; after which the United States shall receive from the beneficiaries a percentage of the net profits from the water-power so developed as a compensation for the resulting injury to navigation on the Great Lakes and connecting waters and loss of water-power on the Niagara and St. Lawrence Rivers, such percentage to be fixed by Congress.

In conclusion the Board deems it fitting to express its appreciation of the ability, energy and care with which its recorder, Capt. G. R. Lukesh, Corps of Engineers, has performed the arduous duties devolved upon him in directing the field work, office computations, mapping and compilations necessary to the preparation of this report.

Respectfully submitted,

Wm. H. Bixby,
Colonel, Corps of Engineers, U. S. Army,
President, Mississippi River Commission.
C. McD. Townsend,
Lieut.-Col., Corps of Engineers, U. S. Army.
J. G. Warren,
Lieut.-Col., Corps of Engineers, U. S. Army.
Henry B. Richardson,
Member, Mississippi River Commission.
Homer P. Ritter,
Assistant, U. S. Coast and Geodetic Survey,
Member, Mississippi River Commission.

## REPORT OF GENERAL BOARD OF ENGINEERS FOR RIVERS AND HARBORS.

The above report was referred, as required by law, to the General Board of Engineers on Rivers and Harbors, for examination and review. This Board presented a report in which it first summarized the report of the Special Board and called attention to the fact that for the cost of a 14-ft. waterway all the way from Chicago to New Orleans, the estimates should be increased by the amounts given by the Board which in 1905 reported on the Chicago-St. Louis section. This would increase the first cost by $30,097,462 and the annual cost of maintenance by $310,000. They also pointed out that the estimates included no allowance for interest or sinking fund charges.

The General Board then presents its own opinions as follows:

The Board of Engineers for Rivers and Harbors now concludes this examination and review of the report before it, with the following opinions and recommendations.

It is practicable to construct and maintain a navigable channel 14 ft. deep and of suitable width from St. Louis to the mouth of the Mississippi River, by either of six methods considered; but is not by the remaining method, that of reservoirs. Of the six practicable methods, the most practicable, having in mind through and local traffic, permanence of location of improved channel, protection of landings, life and property, the general welfare of the community, and possible future development, is the method termed the combined method. Of this, the estimated first cost is, $128,600,000. The annual cost of operation and maintenance will increase as work progresses, and may reach at completion, $6,500,000. These estimates do not include charges for interest and for sinking fund, nor the estimated cost of the waterway from Chicago to St. Louis, which is $30,097,462, with annual cost of maintenance of $310,000.

It is not desirable to construct a navigable channel 14 ft. deep from St. Louis to the mouth of the Mississippi River or from Chicago to the mouth of the Mississippi River. Such a depth is greater than required for successful river navigation and is less than required for economical lake or ocean navigation, and if adopted would require for common use on lake, river and gulf, a type of vessel not now in existence and which if designed would be less economical than modern lake or ocean vessels in use on these waters, or than a towboat and barge navigation on the connecting waterway.

Present demands of commerce between St. Louis and the mouth of the Mississippi River are adequately met by existing projects having for their object to obtain and maintain an 8-ft. channel from St. Louis to the mouth of the Ohio and a channel of not less than 9 ft. in depth below the mouth of the Ohio.

In reporting on the proposed waterway from Lockport, Ill., to St. Louis, Mo., this Board stated:

It believes that the commercial interests of the Great Lakes are entitled to an outlet to the Gulf of Mexico of as great a capacity as can be obtained at reasonable cost. This capacity is now limited by the projected depth between St. Louis and Cairo—that is, 8 ft.—a depth that will not only suffice for a large amount of through commerce, but will be sufficient to materially benefit, and consequently aid in the development of the Illinois Valley. (House Doc. No. 437, 59th Congress, 2d Session).

The Board believes that an 8-ft. channel from Chicago to St. Louis, corresponding to the present 8-ft. project from St. Louis to Cairo, is the least that would adequately meet the demands of commerce, and believes such a waterway would be desirable provided its cost is reasonable. This cost is not now known but will be obtained and submitted before the next session of Congress.

Present and prospective demands of commerce between Chicago and the Gulf will be adequately served by a through channel 9 ft. in depth which may be obtained without violent changes of existing methods of improvement. Estimates of such a through channel have not been prepared and cannot be submitted at this time. They will, however, be obtained and submitted to the Department before the next session of Congress convenes, accompanied by an opinion as to whether this depth is advisable in the interests of commerce, having in mind the cost involved.

The report as to the first four of the specific instructions contained in the Act of March 2, 1907, is concurred in. As to the fifth, it is believed to be practicable to maintain a depth of 14 ft. in the regulated channel, except when interrupted by ice, by the aid of locks and dams similar to those in use on the Ohio River improvement, but this will require wickets 1 ft. 8 ins. longer than those used on the Ohio River, and therefore larger than any that have heretofore been built for river canalization. The difficulties encountered in handling the wickets (already great) increase rapidly with the increase in height. Dredging will be required, possibly to the extent of $200,000 annually. In view of these facts, this Board is of the opinion that the estimates submitted for this system of improvement may be insufficient.

As to the sixth, including the views expressed as to cooperation by the General Government in the plan of the Internal Improvement Association of Illinois, the report is concurred in, except as to the ownership by the people of the United States and Canada, of the power resulting from water diverted from Lake Michigan, and except also, premising such ownership, as to the epoch at which compensation should be received by the Government of the United States. These two points are considered below.

Apart from the plant for its conversion and transmission, water-power depends for its value upon the quantity of water and the height, made effective by structures, through which it falls. The three possible classes of cases are (a) United States owns water only; (b) United States owns structures only; (c) United States owns both water and structures. Should it be determined that the United States, other than as a riparian owner, has no ownership of water, there still remains to be determined whether the United States when acquiring lands upon which to erect locks and dams, as means to improve navigation, does not acquire such complete title to these lands, as to make the United States a riparian owner, with right to charge for water-power created by its dams. But in this case, as the creation of water-power is not essential to Government functions, how far may the use of the power created be regulated or controlled by the owners of the waters, so far as such regulation or control does not interfere with navigation?

Whether the United States, without riparian rights, owns any waters, or has simply an easement, giving it a right to improve channels and conserve the water flowing therein, for purposes of navigation, and to use them for power so far as necessary to operate structures necessary to such improvement, is a subject for judicial determination. Should it be determined that the United States owns any waters used in the development of water-power, any Government charge made for such use should commence with such use, and should not be deferred until the cost of plant by which such use is made possible has been collected from consumers of the power. Compensation if found due, should be fixed by Congress. It should be uniform in the three possible classes of cases.

These questions seem proper for determination before rates for compensation to the United States for water-power can be fixed. General rules, principles, or laws to enable decision to be made as to status of each particular case as it arises, are most desirable.

For the Board,
D. W. Lockwood,
Colonel, Corps of Engineers, Senior Member of the Board.

## REPORT OF GEN. W. L. MARSHALL, CHIEF OF ENGINEERS.

In transmitting these two reports to Congress on June 7, General Marshall briefly reviewed their substance and conclusions and added the following comments:

In the present reports consideration is given to various methods of securing a 14-ft. channel to the mouth of the Mississippi River, all the methods proposed for securing this result being considered by both boards as practicable from an engineering standpoint, except the method of improvement by means of storage reservoirs.

The Chief of Engineers approves the opinions expressed with respect to the methods of improvement considered, with the exception that a long study of the conditions existing on the sediment-bearing Mississippi River leads him to believe that it will not be practicable to obtain a minimum depth of 14 ft. of water between St. Louis and Cairo by means of locks and movable dams. The structures might be built but their efficiency is problematical, and, in the opinion of the Chief of Engineers, the chances of favorable operation are very remote. Nor is the Chief of Engineers prepared to recommend that it is practicable from an engineering standpoint to secure and maintain a 14-ft. depth at low water in the section from St. Louis to the mouth of the Ohio River by any method of open-river improvement.

The special board concludes that the most practicable means of obtaining and maintaining a navigable channel of 14 ft. depth from St. Louis to the mouth of the Mississippi River is by the combined method of dredging and regularization works in the open river. The estimated cost of this plan of improvement is $128,600,000, with $6,500,000 annually for maintenance after completion of the work. In order to arrive at a correct understanding as to the estimated cost of securing a 14-ft. channel from the Great Lakes to the Gulf of Mexico by the route under consideration it is necessary to add to the figures just given those contained in the report submitted in 1905 for that portion of the route from Chicago to St. Louis, namely, $30,097,462 for first cost and $310,000 for annual maintenance, giving a total estimated cost of a 14-ft. waterway from Lake Michigan to the Gulf of Mexico of $158,697,462, with an estimated annual cost of $6,810,000 for maintenance.

The Chief of Engineers is in accord with the views expressed by the Board of Engineers for Rivers and Harbors as follows:

It is not desirable to construct a navigable channel 14 ft. in depth from St. Louis to the mouth of the Mississippi River, or from Chicago to the mouth of the Mississippi River.

The present demands of commerce between St. Louis and the mouth of the Mississippi River are adequately met by the existing projects having for their object to obtain and maintain an 8-ft. channel from St. Louis to the mouth of the Ohio, and a channel of not less than 9 ft. in depth below the mouth of the Ohio.

The Board believes that an 8-ft. channel from Chicago to St. Louis, corresponding to the present 8-ft. project from St. Louis to Cairo, is the least that would adequately meet the demands of commerce, and believes such a waterway would be desirable, provided its cost is reasonable.

Present and prospective demands of commerce between Chicago and the Gulf will be adequately served by a through channel 9 ft. in depth which may be obtained without violent changes of existing methods of improvement.

It should be stated that the report of the special board is regarded as incomplete to the extent that it contains no estimate for channels of 8-ft. depth and 9-ft. depth from Lake Michigan to the mouth of the Ohio River, and no such estimate is included in the report submitted in 1905, hereinbefore referred to. However, on account of the urgent general demand for such information as is available on the subject the reports are forwarded at this time in their present form. An estimate will be promptly made, however, of the cost of a 9-ft. channel from Lake Michigan to the mouth of the Ohio River, which in connection with the present project depth of 9 ft. below the mouth of the Ohio River will provide a depth of 9 ft. from Chicago to the Gulf of Mexico; an estimate will also be made of the cost of an 8-ft. channel from Lake Michigan to the Mississippi River at St. Louis, which latter, in connection with the present 8-ft. project for that portion of the Mississippi River between St. Louis and Cairo, will provide for a least depth of 8 ft. from Lake Michigan to the mouth of the Ohio River. It is expected that these additional estimates will be ready for submission to Congress before

its next session. The Chief of Engineers is not prepared to state definitely for consideration by Congress that the construction of either of these channels is desirable until after accurate estimates are made.

Very respectfully,
W. L. Marshall,
Chief of Engineers, U. S. Army.

June 7, 1909.

## Independent Motor Cars on the Union Pacific Railroad.*

By C. E. FULLER.†

Within the last few years many types of railway motor cars have been designed, built and operated, some with success, but most types have been discontinued after a period of experiment, due to their inability to meet all requirements from a mechanical and operating standpoint. These cars may be divided into three general classes, as follows: (1) Steam motor cars; (2) Internal-combustion motor cars; (3) Electric cars in combination with storage battery, or with one of the above prime movers.

Within the last three years the general trend has been toward the internal-combustion motor.

Quite a number of cars of the internal-combustion motor type are in operation on steam roads in various parts of the country, and the creditable performance of these cars during the last few years has done quite a little to allay the original feeling that the internal combustion motor, as adapted to railway service, would always be an experiment. Some of the advantages of the internal-combustion cars, as developed in the use of this type of car on the Union Pacific R. R. are:

(1) Light motor weight, permitting lighter truck and body construction.
(2) Elimination of the energy-generating unit, such as boilers, tanks and battery.
(3) Convenience and compactness in carrying fuel.
(4) Elimination of smoke, cinders and sound of exhaust.
(5) Instant readiness of car for service.
(6) No power losses nor expenses when shut down.

The present considered standard motor car, put in service by the Union Pacific Ry. is a 55-ft. all-steel car, equipped with 200-HP. motor, and carrying 75 passengers, car weighing 60,000 lbs. A similar car 70 ft. long has been built, seating over 100 passengers and weighing 68,000 lbs. It will be seen that the dead weight carried amounts to from 660 lbs. to 800 lbs. per passenger, which compares favorably with modern automobile practice. Fuel sufficient for a 300-mile run is stored in a single tank of convenient size, located in an out-of-the-way place, and is all fed automatically until the last drop is used. Dead cars have actually been placed in commission on five minutes' notice.

These advantages particularly fit this type of car for operation where fuel cost is excessive or where conveniences for handling and maintaining steam or electric cars do not exist.

At the present time the Union Pacific R. R. has 15 motor cars in service on nine lines varying from 3 to 100 miles in length, and making as high as 390-mile daily runs.

Seven of the earlier cars placed in service on the Union Pacific were equipped with 100-HP. engine. Five of these 100-HP. cars are still in service. The regular or standard type of car in service is equipped with a 200-HP. six-cylinder reversible gas engine, coupled with a Morse silent chain and a friction clutch to the front axle of the car, which carries 24,000 lbs., or approximately 40% of the entire weight of the vehicle, and gives ample adhesion under all circumstances. Two speeds are used —a low, or geared, speed for starting, and a high, or direct, speed for running. Both speeds are available for running backward. The more recent cars differ from the earlier car only in slight details. The side entrance has been introduced instead of rear entrance, with the idea of doing away with the accumulation of ice and snow on car steps, also obviating the use of step box. Smoking compartments have been provided by extending a full partition across the car immediately in front of side entrance, thus isolating the smokers from the rest of the passengers, and this seems to meet with the general approval of the traveling public.

Owing to the fact that some of the services have outgrown the capacity of the 55-ft. cars, we are arranging to introduce a 70-ft. type of car. These cars are operated on branch lines by a crew of two men, consisting of motorman in the engine room and a conducter to take tickets, handle orders, etc.

All working units subject to wear are designed for separate and quick removal, and duplicates of such spare parts kept at terminals for replacements; and, in this manner, the cars can be kept in service almost indefinitely. All parts of motors and transmission being built to interchangeable jigs and templates, the problem of replacements and repairs has been very much simplified.

Where the motor-car service is operated in conjunction with and as supplementary to steam-train service, a straight passenger car is the preferred style of car. Hand baggage can be taken in the car with passengers, and heavy baggage carried on the regular steam trains.

It is not economical to carry baggage on every train where the service is of much frequency. On branch lines where the motor car is substituted in place of a steam train, a combined baggage and passenger motor car is the preferred type. However, on branch lines where there are a number of round trips per day, it may be desirable to carry baggage on only part of the trips, and in such cases the motor car and trailer is the preferred type, on account of the fact that when it is not necessary to carry baggage, the trailer can be cut off and the passenger motor car make the trip alone, thus saving the extra expense of carrying the dead weight trailer.

The motor cars have no difficulty whatever in maintaining a passenger-train schedule, and in addition stopping for passengers, when flagged, at road crossings. This is a great accommodation to the railroad's patrons, and is much appreciated by them. The operation of these cars shows a very heavy passenger traffic development, which, while partially due to the increased frequency of service, is, however, mostly due to the accommodation in making these road-crossing stops. The farmers and those living along the right-of-way, by simply walking to the road crossing, eliminate the necessity of driving to the nearest railroad station.

*Portion of a Committee Report on Motor Cars before Annual Convention of the Railway Master Mechanics' Association at Atlantic City, N. J., June 16-18, 1909.
†Superintendent of Motive Power, Union Pacific R. R., Omaha, Neb.

## Copyright in Drawings of a Technical Character.*

By D. A. USINA,† Assoc. M. Am. Soc. C. E.

The copyright law enacted March 4, 1909, to go into effect July 1, 1909, contains provisions which may be of great importance to engineers, in that it provides specifically for copyright on "Drawings (or plastic works) of a scientific or technical character," and in that the securing of the copyright is made an extremely simple matter.

Prior to the passing of this law there has been no certain protection against the pirating of designs for engineering structures. Where a design though new has involved only the skill of the engineer, it has been unpatentable, and unless the world could be classed under the fine arts there has been no reasonable hope of protection by copyright. In many cases, designs involving a high degree of engineering skill and gotten up at great expense have been copied by others with no moral justification whatever. National, state and city governments and private parties have asked for bids to be accompanied by original designs and have appropriated the design of one bidder and let the contract to another—a species of piracy distinguished legally but not morally from the piracy of works of literature or the fine arts.

It is hoped that the new law will put a material check on such practices by reserving to the proprietor of such drawings the sole right of printing or copying them. It is doubted if the law can be invoked to prevent the building of the structures shown in such drawings, with the possible exception of works which might be classed in the fine arts. The limitations which can be put upon the use of the drawings, however, should afford a substantial degree of protection, and the ease with which copyright can be secured makes it undoubtedly worth trying for whatever protection can be secured.

The language of the Act relative to technical drawings is as follows:

That the application for registration shall specify to which of the following classes the work in which copyright is claimed belongs: * * * (i) Drawings or plastic works of a scientific or technical character.

Taken in connection with the remainder of the law, there is little or no doubt that this language was intended to render such drawings copyrightable. The view of the Register of Copyrights is:

that the language of the Act would authorize the deposit and registration in this office for copyright protection of drawings of a scientific or technical character such as under the present law would not be included in the term "drawing," which seems to be confined to artistic drawings. Examples of such works would be drawings for machinery, for engineering construction, for architectural works, etc. While these drawings have to some extent been registered in the Copyright Office heretofore, it has always been a question whether the law authorized the registration and whether copyright protection would follow.

Protection is extended to "all the copyrightable component parts of the work," such for example as the drawings relating to any complete and mentally segregable part of the whole structure.

Copyright is secured by publication with the required notice affixed to each copy; or, where "not reproduced for sale," by depositing a photograph or other reproduction with the Register of Copyrights. But engineering drawings are usually offered for sale (as part of the bidder's work), and, in such cases, the copyright is secured by affixing a notice of copyright and after thus securing the copyright there must be promptly deposited in the Copyright Office two complete copies.

Several permissible forms of notice are provided. It is sufficient if the word "copyright" be applied to each sheet of drawings, together with the name of the proprietor and the date. It is customary now to apply the name and date to drawings and the addition of the word "copyright" is the simplest matter in the world. For what it is worth (and apparently it will sometimes be worth much), the word "copyright" should be added to all original drawings and copies thereof.

In the case of drawings of especial value, it is advisable also to deposit copies promptly with the Register of Copyrights and to secure a certificate of such deposit, so as to obtain the apparent sanction of the Government, and to indicate such fact on the face of the drawings. For drawings of less value, the depositing of copies may be delayed until it is thought necessary to threaten or bring suit for infringement. The securing of copyright is probably effected by the mere notice. The deposit of copies is an additional formality which, though required to be made "promptly," and though a necessary preliminary step before a suit for infringement can be brought, does not seem necessary to the securing of the right.

Copyrighted works may be sold or furnished to others with any reasonable limitation upon their use. For example, a bidder may furnish an original design with a notice of copyright and a special notice that the copyright and the copies submitted constitute parts of the bid and remain the property of the bidder in case his bid is not accepted, and that the design is not to be copied or submitted for bids from others.

An interesting feature of the new law is the apparent sanctioning of actions against the United States and its officers; but much weight cannot be placed on this construction, in view of the broad prohibition in the general law against actions "sounding in tort" against the United States. Congress has provided no remedy for wrongs committed by the National Government, except for violations of contract, express or implied. The provision of the new law bearing on this subject relates specifically to the recovery of costs in suits for infringement and states that in such suits,

except when brought by or against the U. S. or any officer thereof, full costs shall be allowed, and the court may award to the prevailing party a reasonable attorney's fee.

It is unnecessary to consider the question here at length, but it may be stated generally that after a tort is committed by the United States there is no adequate remedy, but an injunction may be secured against a repetition of it and perhaps, if one has sufficient notice of an intention to infringe the copyright, such infringement can be enjoined in the first instance. Possibly the framers of the law had such injunctive proceedings in view when they framed the above section exempting the United States and its officers from the payment of costs.

The Act provides also that "any person who willfully and for profit" infringes a copyright may be punished by a fine and imprisonment, and an infringer who had received such a special notice as is above referred to would be infringing willfully and for profit and would hesitate to run the danger of fine and imprisonment.

Under the old copyright law, there were only a few cases in which it was attempted to secure a copyright upon a purely technical drawing. It was necessary to enter the drawings in the office of the Librarian of Congress, and the Register of Copyrights permitted such entry only under protest and was of the opinion that such drawings were not copyrightable. The validity of the copyright was generally doubted. The new law, which specifies such works particularly as one of the classes in which copyright may be claimed, and permits the securing of the copyright by applying to the drawings a notice that copyright is claimed, is a material advance toward the protection of a kind of intellectual property of far greater dignity and usefulness than circus posters and similar matters to which the previous law extended protection. To quote the language of the Constitution upon which is based the power of Congress to make a copyright law, technical drawings do more "to promote the progress of science and useful arts" than many of the classes of work for which protection has been heretofore provided.

The practical value of the new law to engineers cannot be predicted. We can only hope. It cannot be used to protect functional equivalents of the thing represented by the drawings. That is the function of the patent law, and protection thereunder runs for 17 years only, while copyrights may last 56 years. It is quite possible for the courts to construe the new law so narrowly as to destroy its value. But it will probably be construed so that it will protect the engineer against the copying by others of the substance or of any material part of his original designs.

*A paper published in the May "Proceedings" of the American Society of Civil Engineers, Vol. XXXV., No. 5, p. 450. This paper will not be presented at any meeting.
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The recent accident to the lock gates of the Canadian Canal at Sault Ste. Marie makes of particular interest the contribution in this issue, in which a new type of balanced gate for canal locks is proposed. The design for the gate is certainly ingenious, but it would be impossible to form any very definite opinion of its practicability until the design was worked out in full detail. Our impression is that it would be very difficult to make a lock gate on this plan which would be thoroughly practicable and safe for very large locks, such as those at the Sault. For canal locks of moderate width and head, however, it seems likely that the design could be made practicable. It may be well to point out that this proposed gate would not be free from the danger of such an accident as that which has recently occurred at the Sault, in which the gates were struck from the lower side. It is fair to say, however, that such an accident is almost or quite unprecedented. Where collisions have occurred previously in canal lock gates, it has been with vessels striking the gates from the upper side. Apart from the author's presentation of his proposed lock gate, his discussion of the design of the Poe lock is of special interest, in view of the meager amount of matter anywhere available regarding the design of modern canal locks.

The vociferous advocates of a sea-level canal at Panama, who broke out with ghoulish glee in a chorus of "I told you so's," when the news came of the accident to the Canadian locks at the Sault, must be suffering keen pangs of disappointment. The "terrible catastrophe," which was to result if ever both gates of a lock should be destroyed and the water allowed to rush through, has now actually happened; and instead of causing wholesale destruction in the manner so graphically prophesied, vessels are now again using the lock, and the total time the lock was out of service was only *twelve days*.

As reported in our last issue, the movable dam above the lock was finally closed on June 12, the third day after the accident. Some hitches occurred in its operation, but all were successfully overcome. On the following day the intermediate gates were closed, and repairs were pushed forward. During the time the waterway through the lock was open, the water flowed through it with a velocity estimated at 15 ft. per second in the lock and 7 ft. in the canal above. This current, however, did no great damage. Apart from the gates lost at the time of the accident, the upper miter wall was slightly damaged, nine timbers were broken in the floor over the culvert and the timber flooring was washed away for 60 ft. The service gate miter-sills were also slightly damaged. New upper gates were placed and other needed repairs were made, the movable dam was raised and swung aside and locking of vessels was resumed on the night of June 21, using for the present the intermediate gates at the lower end of the lock.

But the question may be asked in good faith by some one whether if such an accident as that just recorded at the Sault should occur on the upper lock of the Gatun flight at Panama, the consequences would not be far more disastrous. So much pseudo-scientific nonsense has been written about the dangers of "locks in a flight" that some people have doubtless obtained the idea that the Gatun "flight of locks" will be about as steep as a flight of ordinary stairs, or as the flights of canal locks on some of the small canals such as the Erie.

In answer it may be pointed out that each lock of the Panama flight will be 1,000 ft. long and that the lift of each separate lock is only 28 ft.—or only about 8 ft. more than in the Sault lock. If all the lock-gates were opened and the water of Lake Gatun allowed to rush down through the locks unimpeded, the velocity resulting would be very little greater (for reasons well known to every hydraulic engineer) than resulted in the Sault lock after the recent accident.

It is proper, of course, as has been done at Panama, to adopt means to reduce the risk of collision with the lock-gates toward the vanishing point; but it is proper also to have a clear idea of the probable results of such an accident, should it ever occur, and it is foolish to hold exaggerated ideas of its probable consequences.

Interesting questions regarding the choice of paving material for certain Boston streets and the adaptation of the streets and street plan of the city to meet conflicting interests are set forth in a brief article elsewhere in this issue. The case primarily was between wood paving blocks, which were desired, on account of their noiselessness, by owners and occupants of buildings in the financial district, and granite blocks, which were commended, on account of their being less slippery, by the teaming interests and the so-called humane societies. We say "so-called humane societies" because this seems to be one of many notable instances where an extreme regard for animals has far outweighed all considerations for man. So far as the so-called humane societies in Boston are concerned, this paving question involved merely the saving of possible pain and injury to a few hundred horses at most, compared with the continual nervous strain upon many thousands of business and professional men and women. From this point of view, the name of these societies certainly ought to be changed.

The questions at issue in Boston were far broader than those pertaining to the comfort of either horses or men. They involved vast business interests, engaged on the one hand in the transportation by vehicles of freight and merchandise across the city, and on the other, the unquestionable interference with the conduct of business in the offices in the financial district. That the noise of stone pavements inflicts a business loss in such a section of the city, as well as a loss in human strength and health, is of course indisputable.

It seems very unfortunate, on the face of it, that the financial and general office section of Boston should have established itself so largely in the very path of vehicle transportation. A reading of the excerpts which we give from the report of the Boston Street Commissioners will show that the conditions are greatly aggravated, owing to that utter lack of city plan and regulation of city traffic which is such a curse to most American cities. In this particular case, not only has no adequate provision been made in Boston for so moving vehicle traffic as to make for the economy, convenience and comfort of all concerned, but the situation has been greatly aggravated by permitting the use of streets by steam and surface transportation companies in such a way as to drive vehicle traffic off streets which were formerly used for that purpose and the continued use of which would relieve the congestion in the streets of the financial district. It is high time that Boston and many other of our American cities should wake to the need of thorough revision of their city plan, and also of the provision of adequate means of regulating the use of the streets in the best interests of the whole public instead of allowing them to be monopolized without check or regulation by private interests of one sort or another.

Coming back to the question of paving materials, some of our readers may ask why wood block paving should be used so extensively and with such apparent satisfaction abroad, and particularly in London, with its enormous vehicular traffic, and yet should be so strenuously objected to by the teaming and allied interests of Boston. We cannot speak for a certainty as to Boston, but we know that in New York the wood block pavements are not systematically treated with coarse sand or gravel to prevent slipperiness, as they are in London, and as is considered absolutely necessary there. Why this necessary preventive of slipperiness is not used here we leave our readers to guess; but that this omission militates against the extension of wood block pavements in this country there can be no question.

The complete sterilization of drinking water by heat or by some agent other than filtration has long been the dream of many, and the ambition of a few, of those who are satisfied with nothing short of absolute perfection. We see neither hope nor sanitary need for the achievement of this end, at least when the economics of the subject and other pressing sanitary demands are considered. But the time seems to be rapidly approaching when practical disinfection, or freeing water from substantially all bacteria and probably all disease germs, will be not only possible but actually employed in a large number of cases. Very likely the same process could also be extended to sewage effluents. For the most part, it seems likely that for years to come such water and sewage disinfection will be limited to use under special conditions. For water, in particular, the highly developed and generally satisfactory methods of treatment now in wide use generally yield as satisfactory results as could be reasonably desired, but there are some cases where chemical disinfection, either alone or as a finishing process, might be of great value.

The first large-scale water-disinfecting plant for continuous service to be put in use anywhere in the world, so far as we can learn, was installed in 1908 at Boonton, N. J., by the Jersey City Water-Supply Co. for the treatment of raw water from a large storage reservoir built by that company for the supply of Jersey City. A description of this disinfecting plant, with some notes on the peculiar reasons which led to its installation and on the operating results, is given elsewhere in this issue. This information is in the form of abstracts of papers presented at the recent Milwaukee meeting of the American Water Works Association.

Lest any of our readers unfamiliar with the antecedents of this installation should be misled, we wish to state briefly a few facts and opinions.

The contract entered into in 1899 between Jersey City and the Jersey City Water-Supply Co. was the outcome of many years of bitter agitation and controversy over the introduction of a new and much-needed water-supply for Jersey City. We cannot and need not go into

these controversies here further than to state that one of the points at issue throughout the consideration of the particular source of supply finally adopted, was the danger of its pollution from the population in the towns on the drainage area. It was insisted by some that definite provisions should be made in the contract for the removal or adequate sanitary treatment of the sewage and allied wastes of this population. Instead, a rather vague and general provision, such as was common in water contracts of some years ago (quoted in the first of three papers which we abstract elsewhere) was inserted in the contract. As might have been expected, a provision of this sort, if ever given any adequate attention by the municipal authorities, would lead to litigation such as resulted in Jersey City. It is held by some, however, that the litigation has really been only a means to force down the price which the city is to pay the company when it finally takes over the works. With this contention and related matters we need not concern ourselves here. What we wish to do is merely to call attention to the peculiar conditions which have given rise to the installation of the so-called sterilization plant for the water-supply of Jersey City.

It seems very doubtful to us whether the Jersey City plant at Boonton would ever have been installed under other conditions than those briefly outlined. Perhaps it would, and perhaps the time is yet coming when all unfiltered surface waters, or possibly both filtered and unfiltered, will be subjected to some such disinfecting process. The small cost involved and the reported high bacterial efficiency of the process are certainly both encouraging.

As to the efficiency of the process as applied to the Boonton reservoir water, it should be noted that the bacterial content of the raw water was very low indeed during the period of operation covered by the paper—as would of course be expected from water subjected to a long period of storage. The bacterial content was so low most of the time that the question will rise in the minds of many as to whether any disinfection was necessary. We will not attempt to answer this question, since we understand that litigation over the contract is still pending.

## Why a 14-ft. Deep Waterway Through the Mississippi Valley is Not Worth While.

As the newspapers throughout the country have announced, the much-talked-of project for a 14-ft. deep waterway from Chicago to the mouth of the Mississippi has been unanimously condemned by the Board of Engineers appointed to investigate and report upon it. This Board was created by Congress in 1907, and was appointed by President Taft, then Secretary of War. It was made up of three officers of the Corps of Engineers and two civilian engineers.

The report of this Board when submitted was reviewed by the General Board of Engineers on Rivers and Harbors, and the reports of both boards were submitted to Congress on June 7 by Gen. Marshall, the Chief of Engineers.

All these experts agree in the conclusion that the 14-ft. deep waterway scheme would be enormously expensive for construction and maintenance, and that, when completed, it would furnish no advantage to commerce at all commensurate with its great cost.

The Corps of Engineers is to be congratulated upon this important piece of work. Even more, we believe, the country is to be congratulated in the possession of a body of expert engineers to whom a broad question like this can be referred for investigation and opinion, and upon whom the public can rely with full confidence that the whole subject will be treated with absolute honesty and impartiality.

As is naturally to be expected, the St. Louis and Chicago newspapers which have been most prominent in carrying on the deep waterway propaganda, attempt to discredit these expert reports. President Kavanaugh, of the "Lakes to the Gulf Deep Waterways Association," makes himself ridiculous by declaring that the Army engineers condemned the project because they want the nation's money expended on military works instead of on waterway improvement. He evidently forgets that there are two civilian engineers on the Board! But such attempts to discredit these reports or break their force are too absurd to reach very far. The public knows and Congress knows that the engineer officers have absolutely no interest to serve but the best interests of the nation as a whole. So far as they are tempted to err at all through personal interest, the temptation is to favor large works for navigation improvement, because that is the line of work to which their lives are chiefly devoted and in which their greatest professional interest lies. In fact reports have sometimes been made by officers of the Corps recommending projects which the test of experience afterwards showed to be unwarranted.

We mention this merely to show that if the engineers made any error at all in reporting on the advisability of this deep waterway project, they were most likely to err in its favor rather than against it.

We give up large space in this issue to printing these reports on the deep waterway project, and we may add that this is the first time they have been printed in any such complete form, the newspapers having published only brief extracts. The reports as a whole are a piece of engineering literature well worth the careful study of the profession, even of those who are not especially interested in its subject matter.

More than this, it seems to us that this is one of the cases in which the engineering profession owes a duty to the public. This is one of many topics relating to engineering under current discussion on which people generally, and even the leaders of public opinion, are almost wholly ignorant. If they rely on the newspapers for information on technical matters, it is a case of the blind leading the blind.

Nor are they any better off if they rely on the statements of the salaried advocates who are going around the country booming waterways in general. The average man has not the technical knowledge to enable him to discriminate. When he is told that waterway transportation costs only one-tenth as much as rail transportation, or that if the government would invest half a billion or a billion dollars in waterways the investment would repay its cost to the people every year in reduced rates of freight, he cannot discern the fallacy.

We propound the question, therefore, whether it is not the duty of the engineering profession to aid in the dissemination of sound ideas on technical questions like these. When men of high standing in the profession render an expert opinion on a technical matter of general public interest, does not that opinion deserve the moral support and approval of engineers generally?

And is this not an opportunity as well as a duty for engineers? An engineer may be and should be ambitious to have his statements and opinions held in high regard in his own community and among the circles of his personal acquaintances. One step toward that end is for the engineer to have an informed and intelligent opinion upon the current matters of public interest in connection with engineering works.

Turning again to the report; it is shown by the Board that the probable cost of a 14-ft. deep waterway from Chicago to the mouth of the Mississippi would be, in round numbers, nearly $160,000,000, and that an annual expense of about $7,000,000 would be necessary for maintenance. The Board explicitly says, however, that these statements must be regarded as approximate only. The time and money available for surveys were not sufficient to produce anything more than an approximation to the probable cost. It is quite within the possibilities that the sum named might be far exceeded, particularly if some of the more difficult methods of channel deepening which the Board describes should be adopted.

If this waterway were to bear a huge commerce, such as some of the enthusiastic dreamers who run the Deep Waterways Association have prophesied, there might possibly be some warrant for an improvement of even this enormous cost. But the most telling part of the Board's report is that wherein it presents facts which show indubitably that no such commerce could be expected.

The American public has been deceived for ten years past by the waterway boomers with accounts of the wonderful progress of waterways in Europe, and the great economy with which transportation is carried on in France and Germany because of its improved waterways. The Board shows, however, that the Mississippi River is now and has been for years a far better waterway than any inland waterway of Europe.

Surely, if the claims of the waterway boomers have any sound foundation there ought to have been some slight response to the improvement work which has been done on the Mississippi in the shape of an increase in traffic. Instead of that, however, the traffic has been falling off, year by year, until it has well nigh disappeared. Is there any reason to suppose that deeper water would restore this traffic, or that it would result in a traffic anything like what the waterways advocates have claimed? No reason of this sort is presented. The fact is, as the Board clearly points out, that a depth of water of 8 or 9 ft. is practically as favorable for inland river navigation as a depth of 14 ft.

It must be understood, of course, that these figures of channel depth refer only to the depth of the water on a few of the shallowest bars during a few weeks only of the year. This, of course, fixes the draft to which vessels can be loaded during that time. But during all the rest of the year, and for almost the whole voyage during even the few weeks of lowest water, there is ample depth under the vessel for easy navigation.

We are aware that the argument often presented in answer to the figures of decadent river traffic is that the waterways have fallen into disuse on account of railway competition and the control of the terminals by railway lines. It is true, of course, that the railways have made special rates to meet the competition of water routes, but that does not at all explain the disappearance of steamboat navigation on the Mississippi, provided it really has the advantages so vociferously claimed for it. Our railway managers have no particular prejudice for one form of transportation against another. On the Great Lakes the railways themselves operate steamship lines. Whenever it will pay better to carry traffic by water than by rail on the Mississippi or on the Ohio, we may be sure that the railway companies will be establishing their own lines of steamers on these waters, as they have done on the Lakes and on Long Island Sound.

Another feature of the report which is especially noteworthy, is its insistence upon open-water navigation for the Mississippi instead of any plan of improvement by dams and locks or of lateral canals alongside the river. There are two very strong reasons for this. One is that the alluvial soil of the Mississippi Valley would make the construction of either of these types of navigation enormously expensive and uncertain of maintenance. The second is that the building of a canal alongside the Mississippi River would be well nigh the climax of absurdity. In view of the great advantages of open-river navigation, no vessels would use such a canal even if it were built, save possibly for a few weeks in the year during the period of lowest water.

As to the final fate of the 14-ft. project, there may be an effort by those who have for years been laboring for its promotion to break the force of the Board of Engineers report and secure favorable action by Congress. We see no prospect, however, that such a foolish move can possibly succeed. The facts brought out in the Board's report are so plainly stated, and are so convincing, that it will be impossible to overcome their effect.

The country at large has taken no such intense interest in the project, anyway, as has the Mississippi Valley; and in the present and prospective condition of the Treasury, both Congress and the Executive would be very slow to commit the country to an investment of $160,000,000, even if large benefits were promised as the re-

sult of such an expenditure. But with the highest expert authorities declaring unanimously that this vast sum would be practically wasted if the project were undertaken, those who have led the shouters for "14 ft. through the Valley" must perceive the folly of trying to promote great engineering schemes with hot air alone. Possibly they may yet have the good sense to reorganize the deep waterways movement so that it may be of public benefit instead of constituting, as it now does, a national danger.

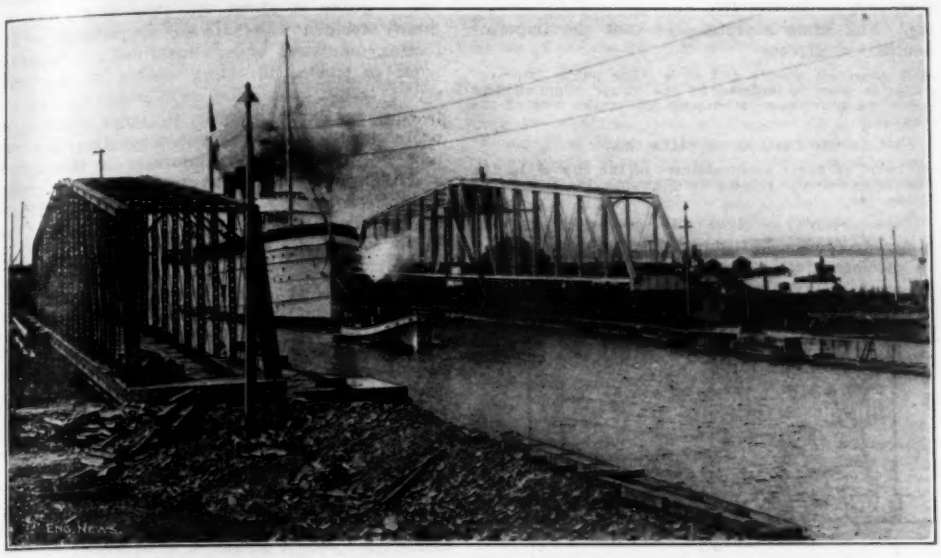


FIG. 1. MOVABLE SAFETY DAM FOR AMERICAN CANAL, SAULT STE. MARIE, MICH.
(Dam frame shown on left. Draw span of railway bridge on right.)
[Copyright by H. G. Tyrrell.]

## LETTERS TO THE EDITOR.

### The Design of Emergency Movable Dams for Canal Locks.

Sir: The accident which occurred to the lock gates of the Canadian canal at Sault Ste. Marie, Ontario on June 9, 1909 (Eng. News, June 17, 1909, p. 673), by which the longest ship lock of the world was put out of service, and the shutting off of the flow through the use of the emergency dam, has brought into notice the question of the design of safety dams for lock protection. The movable dam on the Canadian side, located about 1,000 ft. above the upper set of lock gates, was constructed some years ago for use in just such emergencies as this. On the American side there is a similar safety dam above the two canals. As these dams are very seldom used and there are few such structures in existence, the subject of safety dams has received but little attention.

Some years ago the writer made an exhaustive examination and report on the condition and efficiency of these dams, and because of the service that one of them is now called upon to perform, it may be opportune to recall portions of this report. At the same time investigation was made of upwards of a dozen different forms of movable dams, and two alternate designs with plans and specifications for the same were prepared by him. It is believed that these two designs contain features of merit which are superior to any others in existence at the present.

Since the dams at the "Soo" were constructed, they have been put into use only occasionally for the purpose of retaining the water; when it is desired to clean out the canal or make repairs on the upper gates. This may occur two or three times a year and at such times there is opportunity to test their condition and see that they are in working order.

It is well known that a structure intended for emergency use, only, is frequently found to be out of order. Regular draw bridges that are constantly in use are the ones that are always in order and able to perform their duties when needed. Those which have only occasional use are too often found when needed, to be broken or the parts so rusted that they are not ready for immediate use.

This condition has always existed with the safety dams at the "Soo." The old one on the American side, spanning the canal above the two American locks, was at the time of the writer's examination, in bad repair. A view of the structure is shown at the left of Fig. 1. The truss frame on the other side of the canal is the draw span of the International railroad bridge, swung open for the passage of boats. The safety dam on the left of the picture is constructed on the general lines of an ordinary draw span. It consists of a bridge frame with two parallel trusses, carrying a floor between, for the convenience of workmen when operating the dam. The bridge is mounted on a turntable similar in all respects to that of a highway drawbridge. When it is desired to put the dam in place, the bridge is revolved by hand power through 90°, till the bridge spans the canal. The other end of the bridge serves no purpose than a counterbalance for the end over the canal which supports the dam. Beams are then lowered into the canal, the upper end of which bear against the bridge frame. The frame is then planked over. This work is done in still water with the lock gates closed. When the dam is in position the water may then be drained out of the canal below the safety dam, and the greater part of the flow through the canal will have ceased. I say "the greater part of the flow," for in a temporary dam of this sort there is a very large leakage, which is sufficient to keep a considerable amount of water flowing in the canal even when the dam is in place.

The waterproofing of a temporary dam is the chief difficulty in its design and construction. The dams described above have so large an area of openings that water gushes through the openings to such an extent as to maintain a considerable flow in the canal.

When building a safety dam on the Canadian canal some years later, it was found that there was but little precedent to guide the designer and the Dominion Bridge Co., which built the Canadian dam, followed in a general way the design of the old one on the American side. The chief difference in the two designs is that the newer one is framed in steel, and the water gates are also of steel with buckle-plate faces. Fig. 2* shows the safety dam on the Canadian side in the distance. Beyond the dam is another draw span of the International railroad bridge. This view shows the amount of leakage that forces its way through the openings between the water gates of the dam. This excessive leakage is one of the weakest features of the structure. The design will probably never be repeated, for nearly one-half of the entire length of the structure has no other use than to act as counterweight. It is similar in this respect to canal draw bridges which were frequently built in the same way, before the merits of the more scientific bascule draw were properly appreciated. The trusses are upward of 300 ft. in length. The arm overhanging the canal has 23 gates with a width of 6½ ft. between centers of vertical gate guides, making a total length for the dam of 150 ft. When this bridge is swung into place across the canal, vertical steel gate guides are lowered into the canal, thrusting against bearings on the bottom. It is better, however, that this thrust under water be against a timber bolted to the masonry on the bottom. When bearing against a timber sill, there is less chance for leakage, and the steel gates and girders will bear more evenly against a timber sill than against a solid material. These gate guides are composed of plate girders, built of four angle bars, 5 × 3 × ⅝ ins., and a ¼-in. web plate. On either side of these girder guides are double sets of metal rollers, between which the gates move vertically. This detail is shown in Fig. 3. The guides are 38 ft. in length, and the gates 27 ft. long vertically. Each gate is plated over with buckleplates acting in tension.

When not in use the gates and guides are folded up under the floor and lower bracing, allowing the truss frames and entire structure to be revolved back over the land. The upper ends of these gate guides are supported against a horizontal truss formed of heavy stiff riveted members.

Fig. 2 shows something of the arrangement of trussing, water gates and guide girders. The operation of lowering and lifting the gates is accomplished by means of an ordinary hand power chain hoist attached to a trolley, running on the lower flange of a steel beam. This trolley beam is suspended from overhead framing. The water gates are therefore lifted or lowered singly, and the whole operation of placing the dam occupies upward of half a day.

Fig. 4 shows most of the essential features of the lock. The lower pair of the two pairs of large lower lock gates in the foreground were destroyed by the accident of June 9. There is a third pair of smaller guard gates at the lower end of the lock which are also clearly shown in the illustration. These smaller gates which were swung back against the masonry were not destroyed. It will be seen that all the gates are of the usual wood construction. The lock was completed by the Canadian government in the year 1894. It has a length of 900 ft., a clear width of 60 ft., a depth at sills of 21 ft., and cost about $4,000,000. It is the longest lock in existence.

FIG. 4. VIEW OF LOCK ON CANADIAN CANAL, SAULT STE. MARIE, LOOKING UP-STREAM TOWARD MOVABLE DAM.
[Copyright by H. G. Tyrrell.]

The Poe lock on the American side was completed in 1896 at a cost of $4,000,000, has a length of 800 ft., a clear width of 100 ft., and will admit four large ships at one time.

*This photograph was forwarded to us by Messrs. Young, Lord & Rhoades, photographers, at Sault Ste. Marie, Mich., and we included it in Mr. Tyrrell's account because it illustrated exactly what he wished to show.—Ed. Eng. News.

The old Weitzel lock, also on the American side, which together with the Poe lock connects with the American canal, has a length of 515 ft., a width of 80 ft. in the central part, reduced to 60 ft. at the gates, a draft of 17 ft., and was completed in the year 1881 at a cost of about $2,000,000. It will be seen therefore that while the Canadian lock which was wrecked, has the least width of the three, it is the longest by 100 ft.

The gates for the Poe lock on the American side are made of steel and curved. The gates on the Canadian canal with its width of only 60 ft. are of the ordinary wood construction, and it will therefore not require so long a time to again place the lock in working condition after its recent accident.

Sincerely, H. G. Tyrrell. —
1847 Asbury Ave., Evanston, Ill., June 10, 1909.

[In view of the interest aroused by the accident at the Sault, in the subject to which the foregoing letter refers, a word may be added regarding the design of the movable dams to be built at Panama.

A general idea of the construction of these dams was given in a drawing published in the last annual report of the Canal Commission and reprinted in our issue of Dec. 31, 1908, p. 748. Since that time the details of the design have been very thoroughly investigated by the engineers under Col. Hodges, and a design of dam has been produced which can be operated in much shorter time than that at the Sault. The time estimated by the engineers as necessary for the placing of the dam is about one hour. Means have also been provided for eliminating the large amount of leakage referred to above, so that the dam will be practically tight.—Ed.]

## A Decision Against the Use of Wood Paving Blocks on Certain Boston Streets.

Wood paving blocks for portions of State St. and other short lengths of streets in the financial section of Boston have been vetoed by the Street Commissioners of that city. Wood pavement was petitioned for by owners and occupants of buildings abutting on the streets in question, and, as we understand it, the money necessary to change from granite to wood blocks was put up by private subscription. The construction work had been arranged for, we understand, by Mr. Guy C. Emerson, M. Am. Soc. C. E., Superintendent of Streets. Legal questions were raised as to who had jurisdiction over the material to be used in the repaving. The State Supreme Court decided that this jurisdiction was lodged in the Board of Street Commissioners. This body is elected by popular vote, and consists of three members in whom are vested certain judicial duties connected with the streets, which were formerly exercised by the Board of Aldermen. The statute relating to this Board says that it shall

> lay out, relocate, alter, widen, discontinue or change the grade of highways and public alleys in said city, and order the construction thereof, order specific repairs on highways, lay out sewers, and, with the approval of the mayor, award the damages,

etc. The same statute says that the Superintendent of Streets

> shall construct streets and such other public improvements as may be ordered by the street commissioners under the provisions of chapter 393 of the acts of the year 1906.

The statute further provides that

> the board of street commissioners of the city of Boston may order specific repairs on highways in the city of Boston.

Until recently, action has proceeded on the basis, according to information supplied us by Mr. Emerson, that "repairs were only such as

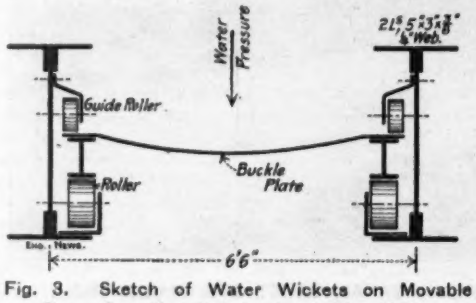



Fig. 3. Sketch of Water Wickets on Movable Dam, Canadian Canals, Sault Ste. Marie.

were necessitated by the relocation, alteration, widening, discontinuance or change of grade of highways." But the Supreme Court decided that a change in paving material constitutes "repairs within the meaning of the statute." The effect of this decision was to open up the question as to what material should be used for repaving State St., etc. The transportation interests of the city, as well as certain so-called humane societies, opposed wood pavement on account of its slipperiness, and were upheld by the Commissioners.

Mr. Emerson informs us, in response to an inquiry of ours, that the decision has no bearing upon the use of wood blocks in other parts of the city. In fact, "wood block has recently been ordered on several streets in the Back Bay district." State St. and the other streets for which the use of wood block was denied "are located in the center of the financial district and are also thoroughfares for a very heavy teaming traffic." The maximum grade on any of the streets involved is about 2¼%, but the upper part of State St., between Devonshire and Washington Sts. (already paved with wood blocks) has a grade of about 4%. The whole case as finally decided was between slipperiness as affecting teamsters and animals and the interests back of them, including delays to vehicular street traffic, and noise or noiselessness as affecting the large number of people engaged in professional and business occupations in the financial district. The interests of the horses and their owners, and of street traffic generally, won. We quote some extracts from the report of the Street Commissioners on the subject, as given in the Boston "Transcript" of June 3, as follows:

> In taking this action the board does so without prejudice and with the hope that some kind of pavement will be found which will eliminate much of the noise now complained of by the business interests in this section of the city, and which will, at the same time, not be injurious to horses. The superintendent of streets stated that he had block pavement in view which, he believes, will greatly reduce the noise occasioned by heavy teams driving over the present granite blocks.
>
> The board recognizes fully the justness of the complaint made by business men in the financial district of the noise now made by teaming over the streets of the district, and it would be pleased to do its part toward giving relief were it possible to do so without injury to other large interests. Wood block pavement is ideal from the standpoint of noiselessness, but it is dangerous to horses and a menace to teaming traffic generally, especially in wet and icy weather.
>
> Not only the master teamsters object to it, but it is also objected to by the Chamber of Commerce and the humane societies.
>
> Unfortunately it seems necessary that the transportation of freight between the north and the south terminals must be through and over such streets as Congress St. and State St. This ought not to be, but there is no help for it unless a teaming artery is established through this section. To obtain such an artery now or in the immediate future seems out of the question because of its great cost.
>
> Atlantic Ave. might be made such an artery were it not that it is so badly obstructed by the cars of the Union Freight Ry., the elevated structure and the surface car tracks of the elevated company. These corporations have been given great privileges in this avenue by acts of the Legislature, and the city of Boston is helpless to

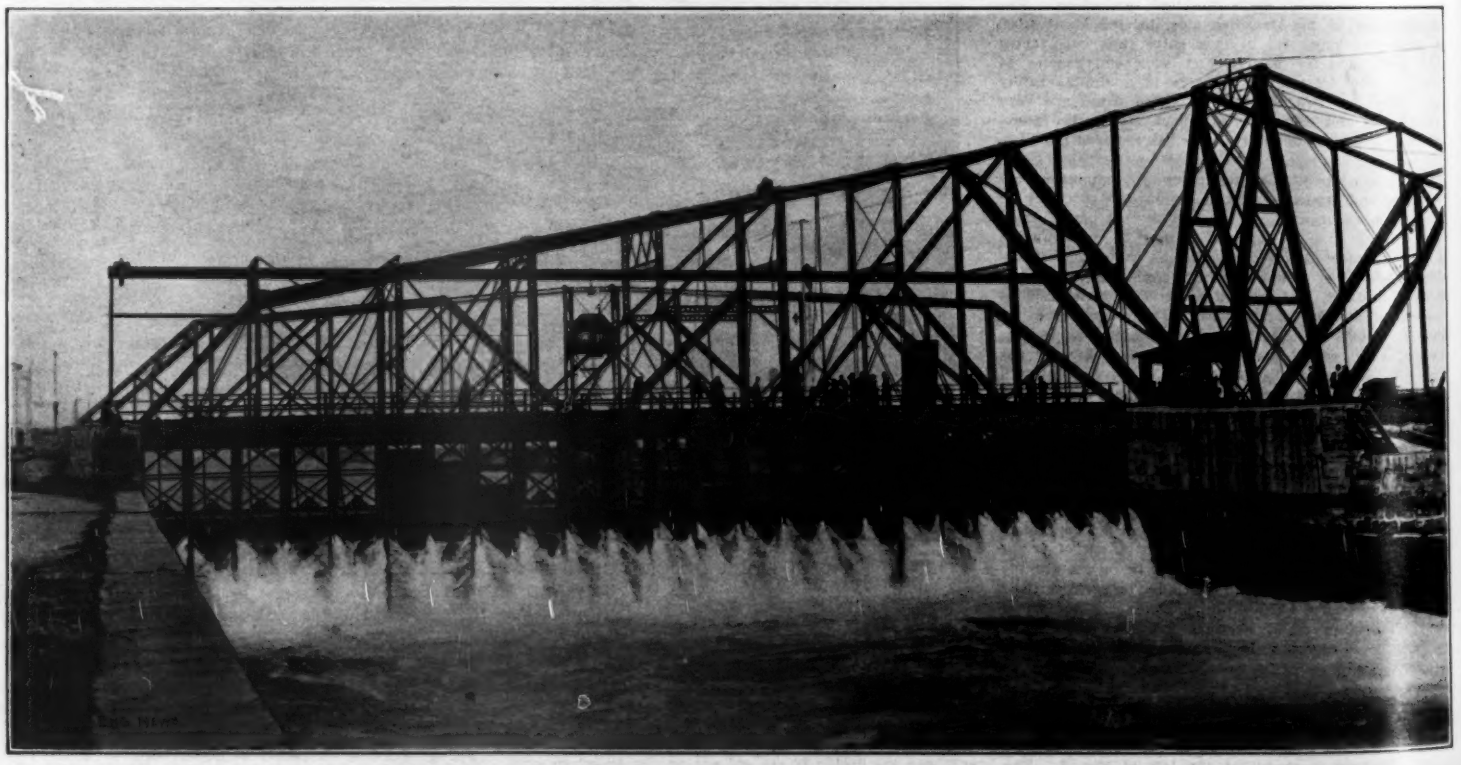


FIG. 2. MOVABLE DAM IN SERVICE ON CANADIAN CANAL, SAULT STE. MARIE.
[Copyright, 1909, by Young, Lord & Rhoades.]

give the teaming interests the relief they ought to have on this important highway. The avenue is used as a freight yard by the Union Freight Railway Co., long lines of cars blocking the way for hours at a time. The surface car tracks of the Elevated Co. are used very little since the elevated trains have been running, and the traveling public would suffer nothing if these tracks were removed. Altogether there are four tracks and the elevated structure in this avenue. It is not surprising that the teamsters refuse it any more than they can help, as when they use it, they run the risk of seriously damaging their vehicles.

Were this avenue put into fit condition to be used for the purpose for which it was intended by taking out some of the tracks and compelling the reasonable use of it by the freight railway, the teaming interests might again turn to it as the main line of freight transportation between the north and the south terminals, thus relieving the financial district of the burden of it.

This cannot be done, however, without special authority of the legislature, and there is some question as to whether the legislature itself can now take from the freight railway company the privilege it enjoys, so broad is the charter given it by a former legislature.

When Atlantic Ave. was despoiled by legislative act the interests of the people of Boston got scant consideration.

Editorial reference to this incident is made elsewhere in this issue.

## The 40,000,000-Gal. Disinfecting Plant of the Jersey City Water Supply Company at Boonton, N. J.*

### Historical and General.

By J. L. LEAL,† A. M., M. D.

Since the latter part of September, 1908, a process of water purification has been in operation at Boonton, N. J., which I believe will be of great interest to scientists and to purveyors and consumers of water. The water treated is the supply of Jersey City, N. J., and is controlled by the Jersey City Water Supply Co. The process employed has been called a "sterilization" process, but is properly one of disinfection. It consists in the addition to the water of so-called "bleach," used in very minute quantities. It is the first time, to my knowledge, that such a process has been applied, as a permanent one, to a water-supply.

There is one instance on record in which the same process was used, as a temporary expedient, during a typhoid fever epidemic due to infected water-supply. This was at Maidstone, England, during the 1897 typhoid epidemic, when a solution of bleaching powder was used by Sims Woodhead for sterilizing the Maidstone water-supply. During an outbreak of typhoid fever in Lincoln, England, in 1904-1905, a solution of "chloros" (a commercial preparation of hypochlorite of soda) was used by Drs. Houston and McGowan, to sterilize the water going to the filters, and also to sterilize the reservoirs. In both these instances good results were obtained.

Dr. Rideal has also used solutions of bleach in connection with the Guilford, England, water-supply, but only experimentally.

Somewhat similar processes have also been tried, with more or less success, on the waters of the rivers Seine and Vanne in France and at Middlekerke and Ostend in Belgium.

Rather extensive experiments were made with solutions of bleach and soda, in the early nineties, by Mauritz Traube, Alois Lode, Sickenberger, Kaufmann, Bassenge, Hunermann, Deiter and Ballner, their object being to obtain practically instantaneous sterilization or disinfection of water for the use of travellers or troops in the field. Their results, although not attaining the end sought, were successful in establishing the efficiency of both calcium and soda chlorides as disinfectants of water.

Electrolytic solutions of sea-water or salt have been used in a number of instances, as at Worthing, England; Nice, France, and at Poplar, England, for general disinfecting purposes, including street watering; for application to sewage effluent at Maidenhead, England; by Rideal, for application to sewage effluent at Guilford, England, and by Woolf, for the disinfection of sewage effluent at Brewsters, N. Y., the disinfection of Jerome Park Reservoir of the New York City water-supply, and for general disinfection purposes at Havana and Vera Cruz.

Solutions of bleach have been used for the disinfection of sewage or sewage effluents on the River Brent in England; at Hertford, England; on the Hooghly River, India; at the Tittagurh installation near Calcutta, India, and at Guilford, England; by Schults of Hamburg in connection with the effluents of hospital sewage works; by Phelps at Baltimore, Md., and Red Bank, N. J.; by Pratt and Kimberly at Camp Perry and other points in Ohio, and by others at numerous places, with generally successful results.

No especial discovery, therefore, is claimed in connection with the process in operation at Boonton, N. J. I do claim, however, that it is the first time that it has ever been used on any such scale, or as a continuous or permanent system of water purification, and I also claim that as a result of the investigations made by us, certain facts in connection with the process have been obtained, which had not been heretofore recognized.

In order to understand the causes which led up to the adoption of this system of purification, it will be necessary to go, very briefly, into history. In the year 1899 the city of Jersey City entered into a contract with a certain contractor for this water supply. Said contractor at once transferred the contract to a corporation which he had organized for the purpose, called the Jersey City Water Supply Co. Work was started by said company, but, becoming financially embarrassed, they were forced to stop. Various attempts were made to finance the project, but all proved failures until in the spring of 1902 the New Jersey General Security Co. was induced to assume control of the Jersey City Water Supply Co. and to fulfill its contract obligations. The work was at once resumed and pushed vigorously to completion in the latter part of the year 1904.

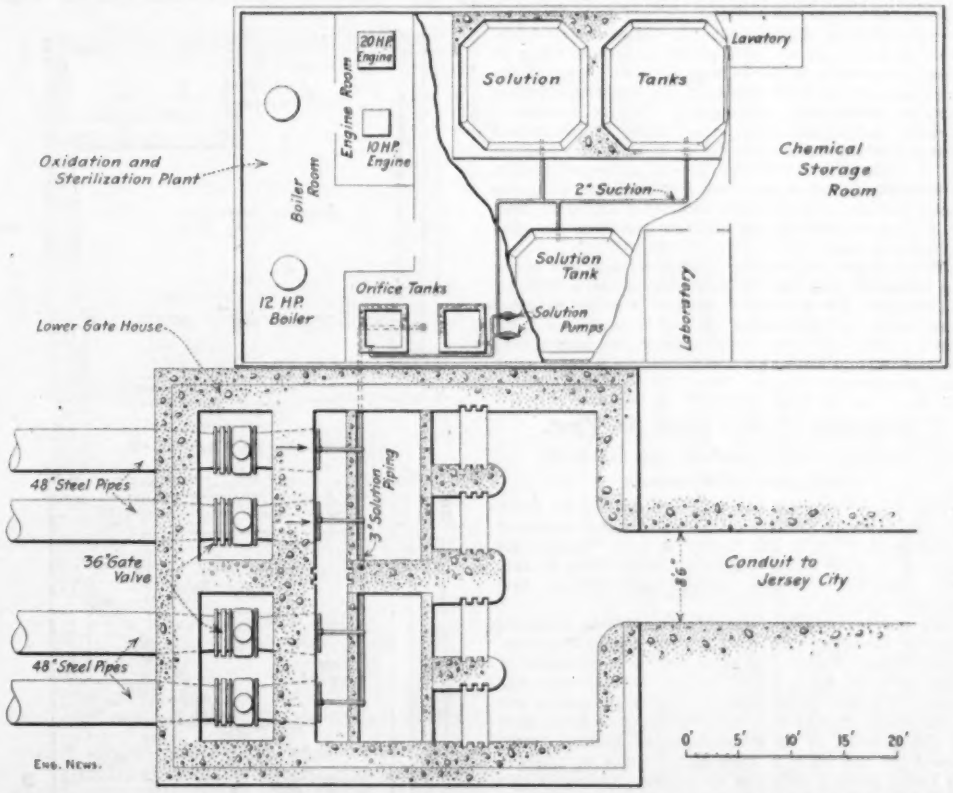



FIG. 1. GENERAL PLAN OF PLANT FOR ADDING HYPOCHLORITE OF LIME OR BLEACHING POWDER DISINFECTING SOLUTION TO THE JERSEY CITY WATER SUPPLY AT THE OUTLET FROM THE BOONTON RESERVOIR.

In the meantime, however, the city had started suit in the Court of Chancery against the company, claiming that the work was not being done according to the specifications and contract. The specifications in said contract with regard to the quality of the water were as follows:

The water to be furnished must be pure and wholesome for drinking and domestic purposes; and the works shall be so constructed and maintained by the contractor that the water delivered therefrom shall be pure and wholesome and free from pollution deleterious for drinking and domestic purposes.

The opinion of the court, rendered May 1, 1908, * * * as to the quality of the water was, briefly as follows:

(a) That during most of the time the water was pure and wholesome, free from pollution deleterious for drinking or other domestic purposes, according to the contract; (b) that owing to certain combinations of circumstances, occurring perhaps two or three times a year (meaning times of high water or flood) the water as delivered at Jersey City contained too high a bacterial count and that B. coli were present in too small quantities of water and was therefore of "doubtful" quality; (c) that the company was obliged under the contract to deliver a water that was on these few days of the year pure and wholesome, free from pollution deleterious for drinking or other domestic purposes; (d) the purification of the water could be effected by means of a filter plant. To construct it and to convey the filtered water to Jersey City, at the head contracted for, would involve a great expense. It would have been so important a part of the scheme that had it been contemplated, it would, naturally, have been mentioned in the agreement. The bill does not pray for any deduction grounded upon its absence. It may, therefore, be dismissed from consideration unless the evidence shows that it is indispensably necessary to a complete performance of defendant's contract obligation. I do not think it does.

The court then goes on to suggest, not as its own opinion, but on account of certain evidence given by the city in the case, that the water on these certain days could be made to comply with the contract by the construction of sewers and sewage disposal works for various towns in the watershed.

I was firmly convinced that such a course would not prevent the conditions criticised by the court, but that after the expenditure of the very large sums of money required to perform such work, the company would be left in the same position as indicated by the opinion; believing, as I did, that by far the greater percentage of bacteria and B. coli found at the point of delivery in Jersey City was due more to the washings of soil, roads, streets, manured fields, etc., than from any sewage contamination, it being understood that there are no sewerage systems in any of the towns in the watershed.

I therefore advised strongly that the court be requested to allow the company to suggest to it its own method for the complete fulfillment of the contract requirements. This prayer was made and granted by the court in the decree filed June 4, 1908, as follows:

In lieu of and as a substitute for all or any of the sewers and sewage disposal works above referred to in this paragraph, the defendant company may, within ninety days from the date hereof, present other plans or devices for maintaining the purity of the water delivered by the company to the city throughout the year, under present conditions, and estimates of the cost of the works now necessary therefor; and both parties may present evidence touching the efficiency of such plans or devices to produce the necessary results, and the cost thereof; and the defendant company may, pending the taking of testimony, with the leave of the Court, upon notice, present amendments and modifications of such plans and devices.

Upon the rendering of the opinion, May 1, 1908, I began to consider the means necessary to accomplish the objects indicated in said opinion. Under all the circumstances, it seemed to me that the method indicated was one of sterilization or disinfection. I had made rather extensive experiments with electrolytic solutions of salt and also with solutions of bleach, as early as 1897 or 1898, in connection with the proposed purification of another water-supply. The results were most favorable from a bacterial standpoint, although the method was not used because it did not fulfill all the requirements of the water under consideration. My first idea therefore was to use an electrolytic solution of salt in connection with the Jersey City supply. I was unable, however, to find a proper cell, and as time pressed, after the rendering of the decree, June 4, 1908, I decided to recommend to the company the use of

*Abstracts of three papers presented to the American Water Works Association, at Milwaukee, June, 1909.

†Sanitary Adviser, Jersey City Water Co., Paterson, N. J.

chloride of lime. * * * The recommendation was approved, and on June 16, 1908, I engaged the firm of Messrs. Hering & F[illegible]ller to design the necessary works, and Mr. Geo[illegible]binson of said firm to operate the same.

* * * * * * * *

This system, whether by the use of bleach or an electrolytic solution of salt, is not by any means applicable to all waters. It does not, in most instances, take the place of filtration, except under certain conditions. It answers the purpose better than anything known, from a sanitary standpoint, but it does not remove suspended matter, nor does it remove color except to a very slight degree. It is applicable to waters from large reservoirs where the water has received sufficient sedimentation and bleaching, and to the waters of large lakes if such waters be satisfactory from the æsthetic standpoint.

I believe that one of its most important uses in the future will be in conjunction with filtration. It will certainly effect any bacterial results required, thus making greater rates possible than with ordinary sand filtration and diminishing the cost, and in mechanical filters making less sulphate of alumina necessary and also allowing greater rates. I know of several mechanical filter plants now about to use bleach in connection with their existing systems, and I also know of a plant building in which it is planned so to do. I personally have used it for a period of several weeks in conjunction with a mechanical filtration plant of the highest type, in which, although the bacterial efficiency was satisfactory, yet on account of the large numbers of bacteria in the raw water, the number in the filtered water was anywhere from 300 to 800. By the addition of the bleach in the amount of 0.35 parts per million, I was able to reduce the amount of sulphate of alumina used and secure an effluent containing anywhere from 2 or 3 to 40 bacteria, the numbers averaging the same in the raw water.

This process will also be used in cases where towns or companies are financially unable to build filtration plants, but are forced for sanitary reasons to adopt some means of purification. It will be used also, I believe, in cases of emergency, where water-supplies have become infected and where it is impossible to cease using such supplies.

## Description of the Process and Plant.

By GEO. W. FULLER,* M. Am. Soc. C. E.

### Nature of Process.

This process is essentially one of oxidation by which the objectionable bacteria in the water under treatment are destroyed. It is also spoken of as a "sterilization process," a name which is quite appropriate from a practical viewpoint, although not absolutely correct theoretically speaking.

The Boonton reservoir water is treated with a minute dose of bleaching powder of a high degree of purity. This compound, commonly spoken of as hypochlorite of lime, is in reality a mixed salt of calcium containing about equivalent proportions of chloride of calcium and hypochlorite of calcium. This compound is acted upon by the moisture in the atmosphere and hence is transported for the trade in tight metal drums to preserve its initial strength so far as practicable. Ordinarily this compound contains some 35% of available chlorine and some 40 to 44% of lime. The remainder is made up of water, part of which is combined with the chemical and part of it is uncombined water in the form of moisture, together with several impurities coming for the most part from the slaked lime used in preparing this salt.

When this applied chemical is dissolved in the water it no longer exists as a mixed salt of calcium, but appears in the form of two salts of calcium, namely, calcium chloride and calcium hypochlorite. The former of these salts remains inert and ineffective as applied to natural waters, and it is the second salt (hypochlorite of calcium) which alone serves as an oxidation and sterilization agent.

When the active portion of the applied chemical, that is, the hypochlorite of calcium, is added to any ordinary natural water such as that in the Boonton reservoir, the free carbonic acid or a half-bound carbonic acid in the water combines with it and there is formed calcium carbonate, and at the same time free oxy-chloride, known technically as hypochlorous acid, is released in the water. This latter compound is spoken of by chemists as an acid, but it is an extremely inert acid, as is shown by the fact that in the atmosphere the applied chemical is decomposed by the very weak carbonic acid contained in the air and there is set free hypochlorous acid in the manner corresponding to that taking place in the treatment of the reservoir water, as above mentioned. This oxychloride or oxy-acid is so unstable that in its pure state it is said to be unknown.

While oxychloride of hydrogen or hypochlorous acid is an extremely weak acid, it is a fact well known to chemists that it is a powerful oxidizing agent. It effects oxidation in the presence of oxidizable substances by virtue of the liberation of nascent oxygen in consequence of its instability as a chemical compound.

At this point it may be mentioned that this treatment is in no sense a chlorine treatment, such as is sometimes spoken of, largely because of the use of the same commercial product in bleaching operations. In bleaching, the commercial product is treated with strong acids which break up the chemical and release free chlorine. Even free chlorine is not of itself an oxidizing agent, but in the presence of water it combines with hydrogen and thus sets free oxygen in an atomic or nascent state.

The weak carbonic acid, the only free acid in the Boonton reservoir water, or other natural water, is entirely incapable of releasing the free chlorine; but instead there is produced hypochlorous acid, as above stated, and it is this weak and unstable oxy-acid or oxychloride which gives up its oxygen to form a powerful oxidizing agent. Hypochlorous acid is not a poison. The chlorine of this compound combines with the alkalinity of the water, forming calcium chloride.

The expression "potential oxygen" has been used on this work to indicate the strength or quantity of oxygen which could be produced from the applied chemical. It is a much more rational expression than the "available chlorine" of the industrial chemists because as applied to water no chlorine as such becomes available.

[Ozone was not used at Boonton because difficulty] in securing its uniform production in a reliable manner has been and still is a serious drawback to its use as an oxidizing and sterilization agent in the field of water purification. For that reason another process was recommended in this case for securing the same working agent by other and cheaper means and in such a manner as to put the control of the treatment within the reach of the operators of the plant at all times.

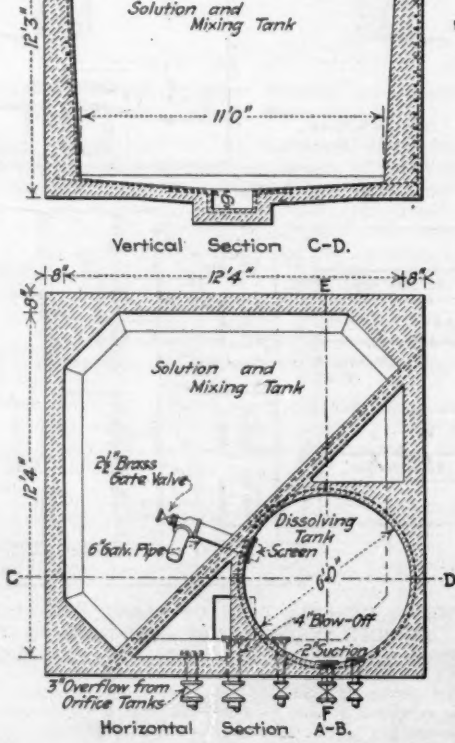



FIG. 2. DISSOLVING AND SOLUTION TANKS FOR HYPOCHLORITE OF LIME, JERSEY CITY WATER-SUPPLY.

### Bacterial Forms.

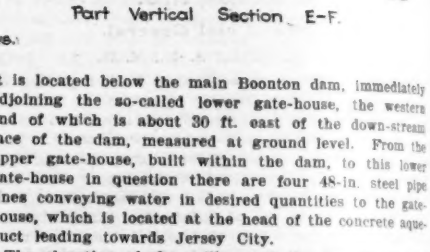
Taking the bacteria as the form of living organic matter of most significance in this problem, it may be stated that bacteria from the standpoint of readiness of oxidation, may be divided into * * * normal or vegetative * * * and "spore" forms. Fortunately in the problem at hand the importance of this bacterial condition is comparatively slight and almost negligible for the reason that the specific germs of intestinal diseases, such as typhoid fever, Asiatic cholera, etc., do not form spores and the same is true of B. coli and the majority of the bacteria which domi[illegible] the intestinal tract of man and domestic animals.

To obtain a clearer conception [illegible]e conditions which actually obtain in a natural [illegible] such as that of the Boonton reser[illegible]oir, especially f[illegible]he standpoint of destroying all bacteria, it is also to [illegible]nted out that the vegetative bacteria, or the norm[illegible]cterial cells, may to a *slight* extent be present in w[illegible] the interior of tiny masses of suspended matter, [illegible] surfaces of which particles may become sterilize[illegible]thout neces-sarily having the active oxidizing and [illegible]rilizing agent penetrate fully within such suspend[illegible]particles.

Bacteria in spore form or contained [illegible]thin particles of suspended matter are not killed [illegible]rely in this process. In making the above statem[illegible] it is not to be inferred that the recommended proce[illegible] suffers in ef-ficiency as to destruction of objectio[illegible]e vegetative bacteria. On the contrary, it confirms [illegible] reliability of its normal action and furthermore explai[illegible]the few resi-dual bacteria which are treated in the [illegible]ater by the process just as they are in the effluents of filters.

### Description of Plant.

This plant was built at the large impounding reservoir on the Rockaway River, a tributary of the Passaic, at Boonton, N. J., about 25 miles west of New York City.




It is located below the main Boonton dam, immediately adjoining the so-called lower gate-house, the western end of which is about 30 ft. east of the down-stream face of the dam, measured at ground level. From the upper gate-house, built within the dam, to this lower gate-house in question there are four 48-in. steel pipe lines conveying water in desired quantities to the gate-house, which is located at the head of the concrete aqueduct leading towards Jersey City.

The elevation of the spillway of the dam is approximately 305 and the center line of these 48-in. pipes is at Elev. 257.25.

The sterilization and oxidation plant was designed to permit the commercial product known as "high grade bleaching powder" or hypochlorite of lime to be dissolved in a convenient manner in tanks located adjoining the lower gate-house, whence the solution is pumped with suitable devices into grids of perforated pipe placed in the mouth of the several 48-in. pipe lines conveying water from the reservoir to the head of the Jersey City aqueduct. Water for the treatment plant is supplied through two 3-in. pipe lines connecting with the 48-in. lines coming from the reservoir, with water under a static pressure of about 15 lbs.

All of the additional works [for the plant] built outside of the gate-house, including the various tanks, pipes, pumps, etc., are included within and beneath a one-story wooden building approximately 33 × 67 ft. in size. This superstructure covers a concrete floor built around and above the various main tanks between which is a pipe gallery. The floor of the boiler, engine and store rooms rest upon an earth fill.

STORE ROOM.—The store room [20 × 33 ft.] has a capacity of three carloads of bleaching powder, corresponding to 120 drums, or approximately 90,000 lbs. This quantity is more than ample to tide over any interruptions in the delivery of this product, as it would provide for over a year's continuous operation with the present volume of water (40,000,000 gals. daily), according to the present dose applied.

DISSOLVING TANKS.—The dissolving tanks [Fig. 2] 6 ft. in diameter and 3.5 ft. in gross depth, are built of reinforced concrete with their tops forming a portion of the floor of the main operating room of the building housing this plant. They are located within the respective solution tanks. Over a portion of the top of the dissolving tanks is a grating made of 2-in. × ⅝-in. steel bars, 3 ins. c. to c., through which the dry chemical is dumped.

SOLUTION AND MIXING TANKS.—These are the large tanks [also Fig. 2] into which the solution of chemical is discharged from the dissolving tanks, for purposes of more complete solution as well as complete and uniform mixing with the aid of stirrers. These tanks, of which there are three, are each 11 ft. 3 ins. deep, 11 ft. wide at the bottom and 12 ft. 4 ins. wide at the top [and each has a capacity of 1,400 cu. ft.].

They are covered with a concrete deck, which serves as a floor of a part of the main room, and in this floor over each tank is a manhole.

STIRRING DEVICES.—Belt-driven rakes with suitable teeth attached thereto [Fig. 3] revolve in the dissolving

*Of Hering & Fuller, Consulting Engineers, New York City.

tanks. Revolving paddles similarly operated in the solution tanks facilitate solution of the chemical and the maintaining of solution of uniform strength.

In each of the three solution tanks are float pipes in which copper floats are placed to actuate a self-recording depth gage order of the standard type made by the Builders Iron Foundry. The dials are 12 ins. in diameter, which is the size of the chart upon which is recorded continuously the depth of solution in tanks. Glass sight tubes are also attached to the sides of the solution tanks.

PUMPS.—The belt-driven turbine pumps have 2-in. connections and have a nominal capacity of 25 gals. per min. They are built of special bronze. One pump is to be used at a time, the other being in reserve. Water coming from the reservoir to the lower gate-house on its way to Jersey City drives a 30-HP. horizontal turbine wheel to develop water needed for pumping and stirring the solutions. Temporarily, two vertical boilers of 12 and 15 HP. and two small engines of 10 and 20 HP. were used.

ORIFICE TANKS.—There are two concrete orifice tanks [Fig. 4] 3 ft. 6 ins. square in plan, and 2 ft. 6 ins. deep. The delivery pipe from the pump discharges into either one of these orifice tanks as desired. An excess of solution is always pumped to them, which excess flows back to the solution tank through a 3-in. overflow pipe.

Each tank is provided with an outlet in the shape of an adjustable orifice, which is made of a special composition of copper, lead and tin and is arranged so that with the aid of a fine micrometer screw a cover is moved backwards and forwards over a slot, thus permitting the use of an area of orifice found to give the desired volume of solution under a constant head. As already explained, the excess volume of solution is taken care of by means of an overflow pipe, thus preventing an excessive head upon the orifice; and any deficiencies in head or depth of liquid over the orifice are indicated almost instantly by a copper float adjusted so as to ring an alarm gong.

Only one device is used at a time, so that as in all other features, the plant is built in duplicate.

PIPING FOR APPLICATION OF SOLUTION TO RAW WATER.—The prescribed volume of solution of known strength flows by gravity from the orifice tanks through a 3-in. galvanized iron pipe line into the screen chamber located beneath the floor of the lower gate-house. This main pipe branches into 4 lines, each 1½ ins. in diameter and extending to a grid fastened over the mouth of each of the four 48-in. mains coming from the reservoir. The grids are made up of 1-in. pipe drilled with ¼-in. openings pointed downward. The grids are fastened in place by ¾-in. wrought iron bars bolted to the masonry.

The solution and the water treated are well mixed before entering the concrete aqueduct.

## Operation of Plant.

By GEO. A. JOHNSON,* Assoc. M. Am. Soc. C. E.

FORCE EMPLOYED.—From Sept. 26 to Dec. 31, 1908, the operation of the sterilization plant at Boonton was under the direct charge of the writer. During that period Messrs. H. C. Stevens and Guy Britton were engineering assistants dividing the duties of the 24 hours of each day, and Mr. L. R. Whitcomb was analyst.

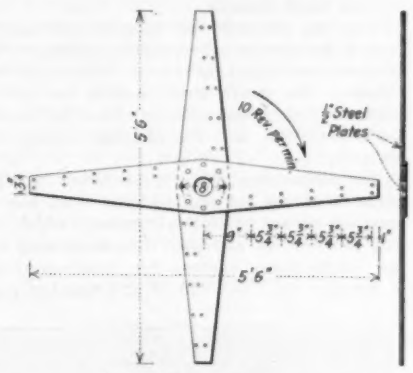
The duties of the engineering assistants were to superintend the preparation of chemical solutions and the application thereof to the water; to prepare accurate records of the rates of application of the sterilizing agent to the water; to collect and test at frequent intervals samples of the chemical solutions in order to ascertain the variation in strength of the same; and to prepare daily reports showing all necessary details of operation. Mr. Whitcomb's duties were to collect and analyze at least once a day samples of the raw reservoir water and of the water after treatment at a point on the aqueduct about one mile below the point of application of the sterilizing agent; and, also, to carry on incidental studies to show the effect of the treatment on particular forms of bacterial life.

CALIBRATION OF TANKS AND ORIFICES.—In the beginning each of the tanks in which the chemical solutions were mixed and stored was carefully calibrated and tables prepared showing the content of each tank at different depths. The orifices whereby the flow of solution was regulated were also carefully calibrated and tables prepared showing the discharge through each orifice under a constant head with the orifice opened to a varying degree. With a knowledge of the amount of water which was being delivered into the aqueduct, it was possible by means of these tables to adjust at the orifice the dose of chemical solution with a great degree of accuracy in a moment's time.

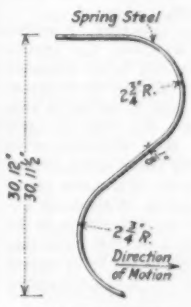
PREPARATION AND APPLICATION OF SOLUTIONS.—The bleaching powder was of high degree of purity, as ascertained by frequent analyses of it during the period of operation mentioned. Ordinarily the powder ran about 35% in "available chlorine," equivalent to 7.9% available oxygen.

In making up a solution the amount of old solution remaining in the tank was first ascertained from the depth recorder and then it was decided to what height the tank was to be filled. By referring to the proper table showing the capacity of the tank between these two gage readings it was then possible to figure the amount of dry bleaching powder necessary to add to make up a solution of the desired strength. This amount of dry powder was then dumped into the dissolving compartment of the mixing tank, raw water turned on, and the agitators started. The solution rising in the dissolving compartment overflowed into the main solution tank, which was filled to the required height through this overflow.

When it was desired to throw a tank into use the proper valves were opened, connecting the suction in this tank with the chemical feed pumps. The solution was tested by the Penot method for its strength in available oxygen by the so-called "available chlorine" method and the orifice on the orifice tank adjusted to give the required dose.




Agitating Arms.




Steel Tooth.

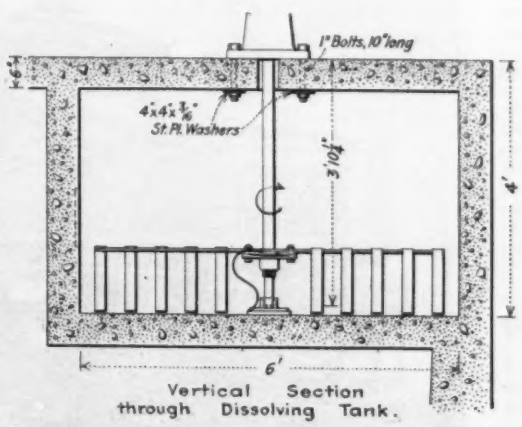



FIG. 3. REVOLVING RAKES FOR STIRRING HYPOCHLORITE OF LIME IN DISSOLVING TANKS, JERSEY CITY WATER-SUPPLY.

The chemical feed pumps were always operated so as to pump a quantity slightly in excess of that discharging through the orifice, and this excess escaped from the tank through an overflow pipe leading back into the main solution tank. In this manner it was possible to maintain at all times a constant head over the orifice and if, for any reason, the feed pumps stopped, the level of the solution in the orifice tank immediately began to fall, causing an alarm to be rung notifying the operator of the fact. Very little trouble was experienced from clogging at the orifice, and the variation in rate of application of the chemical solution was, therefore, exceedingly slight, being practically negligible.

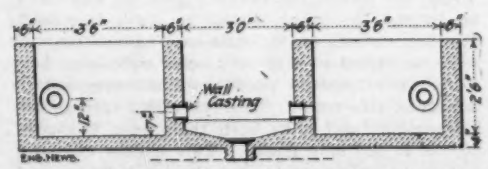



Fig. 4. Orifice Tanks for Maintaining Fixed Head of Hypochlorite of Lime Solution, Jersey City Water-Supply.

In the beginning, not having a thoroughly definite idea of the smallest quantities which could be used with satisfactory results, the amount of chemical applied was 1.4 parts per million of "available chlorine," corresponding to 0.3 part per million of potential oxygen, or 36 lbs. of the dry bleaching powder per million gallons of water treated. Gradually the quantity of applied chemical has been decreased until at the present time about 0.2 part per million of "available chlorine" is being applied. This corresponds to 0.045 part per million of potential oxygen, or 5 lbs. per million gallons of the bleaching powder.

There has been no striking evidence that the higher quantities were more efficacious in the destruction of bacterial life in the raw reservoir water than the small quantity last mentioned.

RESULTS OBTAINED.—The completeness of the sterilizing action, so far as the destruction of objectionable forms is concerned, is apparent from the results presented. [Table omitted.—Ed.] From Oct. 10 to Dec. 31, inclusive, the total number of bacteria in the treated water at the point of delivery in Jersey City averaged 15 per c. c., and only on one occasion out of 455 tests was B. coli positively isolated from the treated water at the point of delivery in Jersey City, namely, on Nov. 1, 1908, when it was isolated in 5 c. c. of treated water collected at the Summit Ave. gate-house in Jersey City. [The bacteria in the raw water ranged from 160 to 1,400 per c. c. in October; 30 to 700 in November; and 240 to 1,600 in December.—Ed.]

Some time after the sterilization plant was put into service studies were inaugurated to demonstrate the efficiency of electrolytically-prepared hypochlorite of sodium. An electrolyzer was obtained from the National Laundry Machinery Co., of Dayton, Ohio, and this machine was set up in the gate-house at Boonton and studies began. This electrolytic cell is of porcelain-lined pottery clay containing carbon electrodes and glass and carbon baffles. A solution of common salt of about 4.5% strength and having an initial temperature of about 65° F. was run through this cell at a rate of about 2 cu. ft. per hr. in the presence of a direct electric current of 110 volts and 22 amperes. The yield of a single cell was about 0.6-lb. of available chlorine per hour.

RESULTS OBTAINED DURING A SPECIAL TEST.—Between the dates March 20 and 24, 1909, a comparative test was made on the raw water to determine the relative efficiency of hypochlorite of lime in the form of bleaching powder and sodium hypochlorite electrolytically prepared. A considerable number of determinations of the bacterial quality of the raw and treated water before, during and after the use of the sodium hypochlorite solution showed that when equal quantities of the germicide in these two forms were added to the raw reservoir water the efficiency, so far as the destruction of bacterial life was concerned, was the same.

COST.—Under the existing circumstances the total cost which can be charged against the process when using bleaching powder was found to be 14 cts. per million gallons of water treated, this figure being divided up substantially as follows, basing the figures on an average daily treatment of 40,000,000 gals. of water:

| | |
|---|---|
| One extra operator | $0.065 |
| Bleaching powder | 0.065 |
| Coal for heating the plant, miscellaneous laboratory and other supplies | 0.010 |
| | $0.14 |

It may be well to point out that power costs nothing at this plant for the reason that it is obtained from a water wheel actuated by the water flowing through the pipes which deliver the water from the dam to the aqueduct leading to Jersey City.

With power costing nothing, the charge for electric current in this process is nil. It has been found that to produce a pound of available chlorine in the electrolytic cell requires about 8.5 lbs. of common salt. This salt, delivered at the plant, costs about ½-ct. per lb.; therefore, the cost for salt amounts to 4¼ cts. per 1,000,000 gals. of water treated. The other figures previously given remain the same, making the total cost by the electrolytic process 11¾ cts. per 1,000,000 gals. of water treated. In neither case has interest on the investment been included nor charges for depreciation in the plant. If this were added the total cost of the process would be between 20 and 25 cts. per 1,000,000 gals. of water treated.

As to depreciation in either process, it may be well to point out that, although the plant has now been in operation over seven months it has not been necessary to replace any of the piping, pumps or valves, and such repairs as have been made are not worthy of mention.

EFFECT OF THE TREATMENT ON THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF THE RAW BOONTON WATER.—In general terms, when hypochlo-

*Of Hering & Fuller, Consulting Engineers, New York City.

rite of lime or soda is added to water the chemical and physical characteristics of the water are changed to some extent. Through the action of carbonic acid, either free or half bound, hypochlorous acid is released from the hypochlorite, and this acid, although very weak, is an active oxidizing agent. In the presence of organic matter its oxygen is released and this attacks the organic matter and oxidizes it. As hypochlorite of lime is a mixed compound, composed of calcium chloride and calcium hypochlorite, it follows that the former will add to the hardness of the water. In the electrolytic process where sodium hypochlorite is produced, the resultant solution contains in addition a slight amount of caustic soda and some sodium chloride, and the hardness of the water would, therefore, not be increased by its addition to it. In both cases the total solids in the water would be increased, and the color, if an organic stain, would be reduced. The carbonic acid in the water would be reduced, since it is essential for the liberation of hypochlorous acid from the hypochlorite.

In more concise terms it may be said that by adding hypochlorite of lime or soda to a water, the organic color thereof will be reduced; there will be an oxidation of organic matter; the carbonic acid will be reduced; the total solid matter in the water will be increased and, in the case of hypochlorite of lime, the total hardness of the water will be increased. With hypochlorite of soda this is not the case. All of the above changes were noted in a series of chemical analyses of the raw reservoir and treated waters. The amounts of chemical applied were so small, however, that the differences in the physical and chemical characteristics of the water before and after treatment were so slight as to be barely noticeable and were well within the limits of accuracy of the methods of analysis.

The most important chemical change which is brought about in this process is the reduction of carbonic acid. This has considerable practical significance from a standpoint of the incrusting and corrosive action of water on iron and steel pipe brought about by the action of carbonic acid.

The claim has been made that free chlorine is liberated in this process, and that it may persist in water treated with hypochlorite of lime. This is in no sense true for the reason that free chlorine cannot be liberated from hypochlorite of lime or soda in a natural water. To do so it would first be necessary to decompose all the alkaline constituents in the water with an excess of strong mineral acid. Again, even if free chlorine could be liberated from hypochlorite of lime in a natural water, the chlorine would immediately combine with the hydrogen of the water and liberate atomic oxygen.

## Electric Locomotive for the Detroit River Tunnel.*

A series of acceptance tests has been recently completed upon the first of six locomotives to be operated by the Michigan Central R. R., one of the New York Central lines, in the tunnel under the Detroit River. This locomotive is claimed to be the most powerful direct-current type yet designed.

The Detroit River Tunnel,† now under construction, will connect the West Detroit yards of the Michigan Central R. R. with the New Windsor yards at Windsor, Ont. The "electrified" zone, embracing the tunnel with its approaches, terminal tracks and sidings, will cover a distance of approximately 33,000 ft. Maximum grades are encountered on the approaches, where a 2% grade extends for approximately 2,000 ft. at each end of the tunnel.

The locomotives are designed for hauling both freight and passenger traffic through this tunnel and also for switching service at the terminals. The specifications according to which they were built demand a maximum service, consisting of hauling an 1,800-ton trailing train, on the 2% grade, at a speed of not less than 10 miles per hour, with two locomotives as a multiple unit. Their capacity was to be such that they were capable of repeating trips with this weight of train continuously, with a lay-over of 15 minutes at each end. The design evolved is an articulated, four-axle, direct-current type, weighing about 100 tons and having a rating of 1,200 HP.

The running gear carries all the traction apparatus and bears all the hauling and buffing stresses. The cab houses the control and auxiliary apparatus. The running gear appears to be two four-wheeled trucks coupled together, but the design of the coupler and the inter-relation of the equalizing systems of each truck make it impossible to consider either truck as acting independently. Both must be considered together as a single, articulated, running gear.

The side frames of the trucks, as may be seen in Fig. 1, are steel castings of truss form. To increase the weight on the drivers the side frames are made heavier than required for the stresses imposed. The top member has a cross-section 5 × 7 ins., and the other members are in proportion. This accounts for the massive appearance of the truck frames.

The end frames and bolsters are castings of heavy box-girder types, rigidly bolted to the side frames and fitted so as to relieve the bolts of shear. The draft gear, buffers and all truck-frame members are calculated for buffing stresses of 500,000 lbs. and for hauling stresses in proportion.

The suspension of the truck frame on the journals is of the locomotive type with the weight carried on semi-elliptical springs which rest on the journal-box saddles. The equalizing systems by which these springs are inter-connected are unusual. The "A" end of the running gear, denoted as the "forward truck" and designated in Fig. 1 by the letter "A" on the corner of the cab extension, is side-equalized. The two springs on each side have their outer ends link-connected to the truck side frame while their inner ends are connected to an equalizing beam which is pivoted on the truck frame. This arrangement may be discerned on Fig. 1. The system on this "forward" truck is designed to equalize the distribution of weight between the two wheels of each side, but virtually making a two-point support for the truck frame and leaving it in unstable equilibrium for tilting stresses.

The "B" end of the running gear, or what may be termed the "rear truck," is cross equalized. The two springs on the rear axle have their rear ends connected to a pivoted cross equalizing bar, while their forward ends are link-connected to the truck side frame. The other two springs are independent and have both their ends link-connected to the side frame. This makes virtually a three-point suspension for the truck frame and leaves it in stable equilibrium toward both tilting and rolling stresses.

The two trucks are coupled together by a massive hinge, so designed as to enable the rear truck to resist any tilting tendency of the forward truck. This hinge combines the two trucks into a single articulated running gear, having lateral flexibility with vertical rigidity. Thus the running gear has what may be called a compound three-point suspension. The rear truck has, in itself a three-point suspension, while the forward and rear trucks together form an articulated frame having a three-point suspension, consisting of the two-point support of the forward truck and the independent equalization of the rear truck.

The braking is mechanically independent on each truck. Two pairs of 12-in. air cylinders work the brakes and separate valves and cut-out cocks are installed so that the pair of cylinders controlling either truck may be independently cut out of service.

The draft rigging consists of standard M. C. B. vertical-plane coupler with yoke, springs and follower plates to comply with the specifications of the Michigan Central R. R. The draft rigging and the spring buffers are mounted upon the outer end frames of the trucks, as seen in Fig. 1. This is to insure that all hauling and buffing stresses are transmitted on the same horizontal line through the draft rigging, side frames and hinge pin of the locomotive. Therefore the center pins and platform framing and cab are entirely relieved of all stresses except those due to the weight of cab, platform and the control and auxiliary equipment.

The cab is supported on the running gear by center pins and side bearings.

Center pins and side bearings are provided on the running gear for the support of the cab. The

FIG. 1. ELECTRIC LOCOMOTIVE FOR THE DETROIT RIVER TUNNEL.
(Designed by the General Electric Co., and the American Locomotive Co.)

center pin on the "A" end is a swivel pin, allowing a turning motion only, while that on the "B" end allows a turning and a sliding motion. This permits the longitudinal motion necessary to take care of the variation in distance between the truck center pins, occurring as the locomotive passes around curves. The side bearings on the "A" end have a clearance of about ⅛-in. when the cab is standing symmetrically, while those on the "B" end have a clearance of about ½-in. The practical result is that, under ordinary circumstances, the cab has a three-point support. The side bearings on the "A" end support all normal rolling actions of the cab and the side bearings on the "B" end come into play under abnormal conditions only.

The cab platform is built of four 10-in. longitudinal channels, running the whole length of the locomotive, which are tied together by the end channels and bolster plates. Such ballast as is necessary to bring the weight of the locomotive up to the required amount is bolted to the two center sills. The space remaining between them forms a passage leading from the blower to the motors for carrying the air for forced ventilation. Two sheets of ⅜-in. steel are riveted to the platform sills and serve to stiffen and square the platform framing. In the operating cab a ⅞-in. wood flooring is placed over the steel floor. The side and ends of the cab are built of ⅛-in. steel plate, supported by a framework of small angles. The roof is of No. 8 steel sheet. The main operating cab occupies the central

*From information furnished by the General Electric Co., Schenectady, N. Y.

†The proposed work was discussed in Engineering News, Feb. 15 and 22, 1906. Details of construction were given in the issues for Oct. 31, 1907, and Sept. 24, 1908. The electrical equipment contracted for and the service for which the locomotives were to be designed were outlined in the issue of May 23, 1907.

portion of the locomotive and covers a floor space of 15 ft. 6 ins. × 10 ft. The windows allow a practically unobstructed view in every direction. Auxiliary cabs extend to the ends of the locomotive with a floor space of 9 × 6 ft. each. These cabs house the air tank, sand boxes, rheostats and contactors. Hinged perforated doors in the sides of the auxiliary cab, clearly shown in Fig. 1, give access to the rheostats and the connections back of the contactors, while folding doors between the auxiliary and main cabs allow access for inspection of the contactors. The edges of the auxiliary-cab covers are bolted to the platform and to the main cab, so that they can be readily removed when it is necessary to make extensive repairs.

The doors of the operating cab open on to the platforms around the auxiliary cabs. At the engineer's seat is the controller, air-brake handles, sand valves, air and electric current gages. Overhead are switches for the headlight and control circuits. Underneath is a pedal valve for raising and lowering the overhead trolley.

A two-stage, four-cylinder air-compressor, geared to a 600-volt direct-current, series motor is located in the center of the main cab. This has two-low pressure and two high-pressure cylinders, so arranged as to divide the work of compression into four equally distributed impulses per revolution. It has a piston displacement of 100 cu. ft. per minute, pumping against a tank pressure of 135 lbs. Circulating pipes are provided for cooling the air between stages and between pump and tanks, in order that the temperature may be maintained at a moderate value.

The motors are of a standard box-frame, commutating-pole type with a rating of approximately 300 HP. At the one hour rating, the motor will develop a torque of 4,050 lbs., at a 1-ft. radius. The gearing between motor and axle has a 4.37 reduction, and the driving wheels are 48 ins. in diameter. With this reduction, each motor will develop a tractive effort of 9,000 lbs. at the rail head, which gives a total tractive effort for the four motors of 36,000 lbs. These figures are for a speed of 12 mi. per hr. The performance at lower speeds may be determined from a study of Fig. 2. The motors have an overload capacity sufficient to slip the driving wheels and the locomotive can develop, at the slipping point of the wheels, an instantaneous tractive effort of 50,000 to 60,000 lbs. The maximum speed of the locomotive running light upon a level track is about 35 mi. per hr.

There are two gears and pinions per motor, one at either end of the armature shaft. This duplication of the transmission gear was used because of the unusually heavy torque and overloads demanded of these motors, it having been claimed that, with a gear and pinion at one end only of the armature shaft, a large proportion of the wear and breakage of pinions is due to the tilting of the motors under heavy loads.

The motor is designed for forced ventilation. Air is delivered into the motor frame at the end furthest from the commutator, passes between the field coils and around the armature, and finally escapes through suitable discharge openings in the frame, over the commutator. The blower has a capacity of 2,000 cu. ft. of air per minute at 2¼ ins. water pressure and is driven by a direct-current series motor.

Multiple-unit control apparatus is installed with jumper-cable boxes at the ends of the cab platform, so that two or three locomotives may be operated as a single multiple unit if desired. The controller steps were apportioned with a view of producing uniform speed and torque increase during the acceleration period. With a string of 40 or 50 cars, a total weight up to 1,500 tons, it is necessary to avoid great inequalities of starting torque to avoid waves of buffing stresses in the long and elastic train. Otherwise, on account of such waves, the stresses in some part of the train rise to an abnormal value. The controller combinations are arranged so that the motors may be operated four in series, two in series and two in parallel, or four in parallel. There are nine resistance steps in series, eight in series-parallel and seven in the parallel position. Fig. 2 shows the results obtained by this control. Here are speed, current and tractive effort curves obtained in the acceleration of a train of 1,578 tons, consisting of the locomotive and 26 freight cars, from a standstill to 10 mi. per hr. It is to be noted that the maximum increase of the draw bar pull is about 6,500 lbs. on the first few steps, after which the maximum throughout the remainder of the acceleration is from 2,000 to 3,000 lbs. The practical effect of this smooth acceleration appears to an observer standing in the caboose of such a train as the last end of the train is started so gradually that the beginning of the motion is almost imperceptible. The driving current is to be normally taken from an inverted third rail through shoes, but a small pantagraph collector is mounted on the roof for certain yard cross-overs.

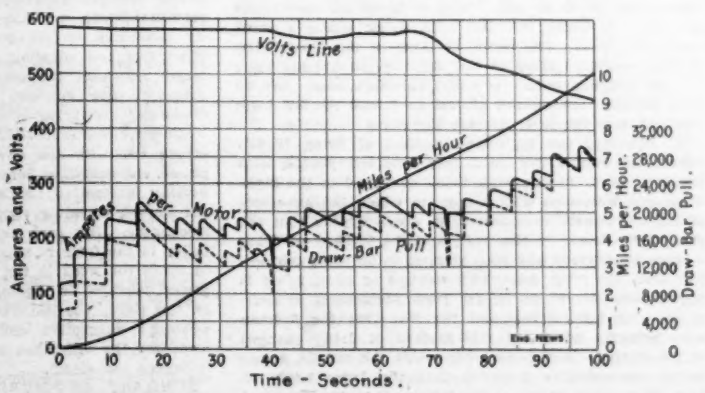



FIG. 2. RESULTS OF ACCELERATION TEST OF DETROIT RIVER TUNNEL LOCOMOTIVE.

(Locomotive No. 7500; total weight of locomotive and 26 freight cars, 1,578 tons.)

Locomotive dimensions are given below.

| | | | |
|---|---|---|---|
| Number of motors | 4 | | |
| Gear ratio | 4.37 | | |
| Number of driving wheels | 8 | | |
| Diameter of driving wheels | 48 | ft. | |
| Total wheel base | 27 | ft. | 6 ins. |
| Rigid wheel base | 9 | ft. | 6 ins. |
| Length inside knuckles | 39 | ft. | 6 ins. |
| Length of main cab | 15 | ft. | 6 ins. |
| Height of cab | 12 | ft. | 6 ins. |
| Maximum height, trolley up | 15 | ft. | 6 ins. |
| Maximum height, trolley down | 14 | ft. | 10¾ ins. |
| Maximum width | 10 | ft. | 2⅝ ins. |
| Width of cab | 10 | ft. | 1 15/16 ins. |
| Total weight | 199,000 | lbs. | |

This locomotive is the joint production of the General Electric Co. and the Schenectady Works of the American Locomotive Co.

THE "CLERMONT," replica of Robert Fulton's famous steamboat, which will play an important part in the Hudson-Fulton celebration this fall, is being built at the yards of the Staten Island Shipbuilding Co., New York City. The boat will be ready for launching early next month and the interior work and the installation of the engine will be completed after it is afloat. At present her keel is laid, her planking is on, her bottom boards are placed and the construction of the interior has been begun. The bottom of the boat is absolutely flat for its entire length, the sides are almost perfectly perpendicular and the bows are sharply wedge-shaped. Despite her strange appearance those in charge of the work declare that she is remarkably sea worthy. Most of the parts of the reproduction of the engine have been made and are ready for installation. The old-fashioned boiler is about finished and but for the installation of certain safety devices, now required by law, but unknown in Fulton's time, the "Clermont" will be seen as on Aug. 17, 1809, when she made her first trip.

EIGHT SEWAGE AND FIVE WATER PURIFICATION plants were built in Ohio in 1908, and 47 and 30 plants, respectively, were in operation at the close of the year, while ten sewage disposal and three water purification plants were under construction.—Byron Stanton, M. D., Pres. Ohio State Board of Health, in Quarterly Bull. O. S. B. of H., January-March, 1909.

## Annual Convention of the American Railway Master Mechanics' Association.

The 42d annual convention of the American Railway Master Mechanics' Association was held at Atlantic City, N. J., June 16-18, 1909. At the last annual convention of the Association there were many guarded statements and a general under-current of feeling that that would be the last convention at which the Association would meet as a separate body, and it seemed to be understood that all of the various railway societies were to be combined under the general head of the American Railway Association. This anticipated combination has not yet been brought about, nor does it seem to be an event of the near future. The only suggestion of this sort at the present convention was the amendment to the constitution which provides that the Executive Committee shall

determine which, if any, of the subjects presented at the convention, or by the members, shall be referred to the American Railway Association

and a suggestion of the President, to be referred to later, relative to combining the Association with that of the Master Car Builders.

The society is in a prosperous condition both as regards membership, which has increased from 902 last year to 961 this year, and as regards finances. Through a legacy of the late Emma A. Tillotson, widow of Luther G. Tillotson, the Association received $5,000, the interest on which is to be devoted to such scientific investigations as the Executive Committee may recommend. It was reported that during the past year two past-presidents of the Association had died, Mr. R. H. Soule, who was President, 1896-97, and Mr. G. W. West, President, 1902-03.

PRESIDENT'S ADDRESS.—The annual address of the President, Mr. H. H. Vaughan, Assistant to the Vice-President, Canadian Pacific Ry., was a comprehensive, thoughtful paper. After tracing the history of the Association since its foundation in 1868, and recounting the valuable work it has done in the past, Mr. Vaughan proceeded to suggest wherein lies the future work. In the past all attention has been paid to technical considerations. While these must not be neglected in the future, Mr. Vaughan thinks that economic necessities are now so closely interwoven with technical problems that the two are equally important. He said:

Without in any way reducing the interest we have in locomotive engineering, we must take up in a far more businesslike and serious way the financial problems connected with the operation of the locomotive department, the form of organization that will give the best results, the commercial aspect of the work of a motive power official in conducting his department as though he were manager of a large business enterprise.

The specific questions which he recommended for future consideration were: the study of the articulated locomotive: investigation of the engineering side of electric operation so that the mechanical officials may be of use to the management in deciding upon where and when to install such operation; and the study of systems of operation and organization. He also recommended that a closer relationship be brought about between the various railway clerks and the Master Mechanics' Association.

Finally, Mr. Vaughan brought up again the old question of the amalgamation of the Master Mechanics' Association and the Master Car Builders' Association. These two societies are very closely allied in membership and interests, their conventions are always held one immediately succeeding the other at the same place and with the same exhibit of railway supplies serving each society. There seems to be no other than a sentimental reason why they should not be joined into one society, to be known, perhaps, as the American Railway Mechanical Association, in which each would have an equal part. The matter was referred to a special committee which is to confer with a committee from the other association, a report to be presented next year.

MECHANICAL STOKERS.—The report of the committee on this subject consisted of progress reports on two or three of the various types of stokers now on trial in the various roads and included a tabulation of tests on one of these types.

In connection with its study the committee directed attention

to the fact that automatic stokers are in their infancy, and it should be realized that efficiency over hand firing could hardly be expected at such an early stage, and furthermore that the tabulated results hold out great hopes for the future, particularly as the question has been taken seriously by a number of railroads. . . . A successful automatic stoker should render locomotive firing more attractive, raise the standard of the service, permit close attention to economic handling of fuel and reduction of black smoke, enable firemen to become better acquainted with the general duties of a locomotive engineer, and reduce tube and fire-box troubles.

One device, the Strouse Overfeed Stoker, was especially praised in the ensuing discussion.

This stoker is of the steam-driven horizontal reciprocating plunger type. The coal is fed through a detachable hopper to the plunger distributor, which distributes it in the fire-box by the forward movement of the plunger. The fire-box door is replaced by a special door hinged at the top and opening inwardly, being operated automatically. In event of resorting to hand firing the suspension rods which support the stoker in position are disconnected, the stoker moved into the gangway and the original fire door reapplied. The stoker successfuly handles any grade of coal from slack up to what will pass through a 5-in. screen.

A number of these stokers have been installed on the Chicago & Alton R. R., both on freight and passenger locomotives, and insofar as the limited time has allowed, have proved as satisfactory as could be expected for an appliance in the first stages of its development.

It was especially emphasized that the mechanical stoker is not as yet a fuel economizer or a smoke-consumer, but that it is a labor-saving device and it does ensure even and regular firing.

MOTOR CARS.—The report of this committee consisted mainly of a description by Mr. C. E. Fuller, the Superintendent of Motive Power of the Union Pacific R. R., of the gasoline-driven motor cars used on that road. This description we reprint elsewhere in this issue. There was also included a list of questions concerning the desirability and design of such cars, which is to be sent out to members, the answers to be used by the committee in preparing its next year's report.

From the discussion it is evident that the independent motor car is a feature of steam railroading that is to be considered in the future, though its use must be limited to a very narrow field. On certain short lines, subjected to numerous stops and remote from adequate yard and shop facilities, there seems to be a use for the individual car which does not require much attention and is always available. This car must be treated, however, as an individual, with perhaps a single trailer, and not considered as a diminutive locomotive capable of drawing small trains. If this latter is resorted to the ordinary locomotive will prove more economical and serviceable. One member pointed out that the great need in motor car design at present was one which could be operated in either direction, thus obviating the present necessity, with one-direction car, of Y's or turntables.

STANDARD METAL AND WIRE GAGE.—In the report of the Committee on Revision of Standards attention was called to the fact that most railways were disregarding the standard decimal gage on sheet metal and iron which the Association adopted some years ago. Complaint has been made by the Association of American Steel Manufacturers that there is a wide variation among different railways in the gage used in ordering material. A committee was appointed to look into this matter and to act with the proper committees from responsible societies to adopt uniform standard gages which will be used by all railways.

BANK VS. LEVEL FIRING.—In an individual paper by Mr. E. D. Nelson, Engineer of Tests of the Pennsylvania R. R. Co., comparison is made between the efficiencies of bank and level firing, using for a basis a series of tests carried on in the testing plant of the road.

The method referred to as bank firing consists in building up, at the back end of the fire, a bank or ridge of fuel, just inside of the fire door. This ridge of fuel when built up to its full height, has its top at about the level of the top of the fire door. Coal is fired over the top of this bank and slides down the incline toward the front of the fire-box, being assisted by the slope of the grate. Coal is distributed along the ridge or bank and finds its way down to the level portion of the fire at the front end of the grate.

The claims of superiority for this method over the level firing, are as follows: The fuel, heaped up at the back of the fire-box, is coked, the hydrocarbons are driven off slowly and, traversing the whole length of the fire-box, are burned with little smoke; the bank of green coal, extending up over the door opening, protects the fireman from part of the heat that is radiated from the fire; the work of placing the fuel is simplified, the coal being fed to the top of the bank instead of being distributed over the grate.

The conclusions from the test made with firemen advocating each style of firing are as follows:

It should be emphasized particularly that in speaking of bank firing as a method, the size of the bank which is to be employed must be clearly understood. The general statement that bank firing and level firing can be placed on a par, so far as economy in fuel is concerned, is misleading, unless a description of the bank method of firing is given.

The idea of the larger bank seems to be that it forms some protection for the fireman against the heat from the fire-box and permits the firing to be done largely at the back end of the fire-box, the coal or partly consumed coal working its way forward. This method of bank firing has been shown to be uneconomical.

The method of bank firing with the low bank does not require all the coal to be fired at the back end, but requires firing in much the same way as with the level fire. The temperature from this form of bank has been shown to be from 10 to 23° F. less near the fire door than with the level fire.

Of the two methods of firing, the results for the bank firing as practiced at the locomotive testing plant during these tests, show a slightly higher evaporation of water per pound of coal. This is based on the results of the level firing and the bank firing where a short bank was used. The result in favor of the bank firing is due, possibly, more to the skill of the fireman than to the methods used. It would, therefore, seem safe to conclude that the amount of coal used with the low bank fire and with the level fire are the same.

If, however, the high-bank method of firing is followed, the results are much less satisfactory than with the level fire. As the bank firing employed in the high-bank test was used with a coal to which the advocates of bank fire were accustomed, it would appear that the size of the bank, in this test, and the method of firing it were that which had been claimed to be more economical than the level fire. This method of bank firing is undoubtedly proved to be far from economical as compared with level firing, and the fact that the fireman who formerly advocated this method of firing changed to the small form of bank after seeing the results, seems to be corroborative evidence that the large bank, as first tried, was, in his estimation, not to be compared in economy with level firing.

SUPERHEATERS ON LOCOMOTIVES.—The committee on this subject reported that, on account of the business depression during the past year, it had been unable to carry on any experiments along this line, but hoped during the ensuing year to get data on road performance of locomotives equipped with boilers.

A very valuable individual paper was presented by Prof. W. F. M. Goss, Dean of the College of Engineering, University of Illinois, on "Locomotive Performance Under Saturated and Superheated Steam." This report is an abstracted account of two series of tests undertaken for the Carnegie Institution at Purdue University on a locomotive working with saturated steam and another locomotive equipped with a superheater. The results of the tests with saturated steam has already been reported *in extenso* in a publication* of the Carnegie Institution and the second series is the subject of a book† now in press. The report to this Association, then, is only a limited portion of the completed report, but even in its present shape, it is much too long (48 pp.) to permit of more than a brief account here.

The two locomotives tested were identical except for those details of construction involved by the presence of the superheater. There was a heating surface of 1,322 sq. ft. on the saturated steam locomotive and 1,216 sq. ft. on the superheated steam locomotive, made up, in the latter case of 1,023 sq. ft. water-heating surface and 193 ft. of superheating surface. At the end of his paper Prof. Goss makes a comparison of the two tests, from which we abstract the following salient points.

The saturated steam test was made on Locomotive No. 2; the superheated steam test on Locomotive No. 3.

COMPARISONS OF BOILER PERFORMANCE.—When both are worked at the same rate of power, the combined boiler and superheater of No. 3 [illegible] not less efficient than the boiler of No. 2, and according to the data at their face value,* it shows that its efficiency is greater by approximately 4%.

COMPARISONS OF ENGINE PERFORMANCE.—The saving effected by the use of superheated steam (as shown by steam consumption per I. HP.) when the pressure is 120 lbs. is not less than 12% and when the pressure is 240 lbs. approximately 2%. Under a boiler pressure of 180 lbs., the substitution of superheated steam for saturated steam improves the efficiency of the engine 9.1%. The results show, also, that the performance of the superheating locomotive is affected by changes of pressure to a much smaller extent than that of the saturated steam locomotive.

COMPARISONS OF THE LOCOMOTIVES AS A WHOLE.—The performance of the locomotive as a whole is shown in terms of coal consumed per I. HP. for both types. These data show that there is a gain resulting from the use of superheated steam. This is most pronounced at the lower pressures. Thus, at a pressure of 120 lbs. it is 17%, while at a pressure of 240 lbs. it is but 6%. The performance of the locomotive using superheated steam is only slightly affected by changes of pressure for the entire range of pressure between 120 lbs. and 240 lbs. With superheated steam the difference in coal consumption from minimum to maximum is but ½ lb., while for pressures between 175 and 225 lbs. it is practically constant and always near the minimum. The least coal consumption per I. HP.-hr. is 2.97. It was obtained under a steam pressure of 200 lbs. The results sustain a claim which has been put forward by advocates of the practice of superheating to the effect that the adoption of such practice permits a material reduction in steam pressure as compared with pressures now common in locomotive service without materially sacrificing efficiency.

COMPARISONS INVOLVING CAPACITY.—It has been shown that, for the development of equal amounts of power, the combined boiler and superheater of the superheating locomotive has an efficiency which, if it does not exceed, certainly equals that of the saturated steam locomotive. But each unit of power delivered from the boiler in the form of superheated steam is more effective in doing the work in the cylinder than a similar unit of power delivered in the form of saturated steam. Hence, at the limit, the superheating locomotive is the more powerful locomotive and the gain equals that which measures the difference in the economy with which the cylinders use steam.

SUMMARY OF SIGNIFICANT CONCLUSIONS.—The substitution of superheated for saturated steam under conditions where the power to be developed is fixed, will permit:

1. The use of comparatively low steam pressures, a generally accepted limit being 160 lbs.
2. A saving of from 15 to 20% in the amount of water used.
3. A saving of from 10 to 15% in the amount of coal used while running, or of from 8 to 12% in the total fuel supplied.†
4. Assuming the power developed to equal the maximum capacity of the locomotive in each case, the substitution of superheated for saturated steam will permit an increase of from 10 to 15% in the amount of power developed, accompanied by a reduction in total water consumption of not less than 5% and by no increase in the amount of fuel consumed.

FUEL ECONOMIES.—The report of the committee on this subject aroused a great amount of interest on the floor. It is evident that the mechanical officials of railways are fully aware that there is an immense saving possible in the cost of coal and that every road is carrying on investigations and experiments to determine where and how this saving may be made. The report comprises the answers to a number of questions concerning fuel purchase and consumption and concludes with the proposition that:

The proper essentials of fuel economy and the conditions obtaining in a locomotive boiler on which that depends, should be as follows:

(1) A clean boiler whose shell tubes, sheets and stays are kept free from mud and scale.
(2) Properly drafted and good steaming engines.
(3) A good quality of fuel properly prepared for use.
(4) Efficient operation of the locomotive.
(5) Individual fuel records.
(6) A full and fair accounting.

Of the six possible lines of saving it was very evidently the opinion of the convention that the fourth was the most difficult. It is possible to get good coal and good engines by proper care, but with all these perfect, poor results alone can

*"High Steam Pressures in Locomotive Service," published by the Carnegie Institution, Washington, D. C.
†"Superheated Steam in Locomotive Service," published by the Carnegie Institution, Washington, D. C.

*As noted, the heating surface on No. 3 is less than on No. 2. The data show a higher efficiency for the former, but Prof. Goss has reduced them to the same basis, with the above results.—Ed.
†Because in road use about 20% of the fuel used goes toward losses, stops, waits, firing up, etc., which cannot be saved by the use of a superheater.—Ed.

be expected unless the men, the engineman and the fireman and the roundhouse foreman, are efficient. And this efficiency is not a question of knowledge so much as it is a question of performance. As one member said on the floor, "It isn't hard to teach men to know a thing, it is hard to get them to do what they know."

The subject of fuel economy was continued as a committee subject for further report next year.

The Committee on "Tender Trucks" submitted a report embodying certain recommendations for the design of tender trucks which would tend to make them more long-lived and safe. The ensuing discussion was somewhat emphatic and the convention voted that the whole matter be submitted to the Executive Committee before any publication be made.

The committee appointed to report on "What Progress Has Been Made in Lubricating-Material Economics" presented a historical account of locomotive lubrication from the earliest days to the present time. The Committee on Castle Nuts reported some revisions of standards and the Committees on Locomotive Safety Valves and on Widening Gage of Track on Curves presented progress reports and were continued. A paper by Prof. Charles E. Lucke, Columbia University, New York, on "Heat Transfer," was presented to the convention and accepted but not read.

OFFICERS.—Pursuing the recent policy of electing to office the higher officials in the mechanical branch of the railway service, the Association named the following officers for the ensuing year: President, G. W. Wildin, M. S., N. Y., N. H. & H. R. R.; 1st Vice-Pres., C. E. Fuller, S. M. P., Union Pac. R. R.; 2d Vice-Pres., H. T. Bentley, A. S. M. P., Chicago & N. W. Ry.; 3d Vice-Pres., D. F. Crawford, G. S. M. P., Pennsylvania Lines. Mr. Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill., and Mr. Angus Sinclair, were retained as Secretary and Treasurer, respectively.

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A NUMBER OF RAILWAY ACCIDENTS have been reported during the past week. Two trolley cars on the Chicago, Lake Shore & South Bend Ry. collided head-on June 19 near Dune Park, Porter Co., Ind. Ten persons were killed and 40 others were injured. The accident occurred at night and, at the time of the collision, the westbound car had been stopped while the eastbound car was running at a speed of about 50 mi. per hr. Reports state that the motorman of the westbound car saw the approaching headlight of the other in time to bring his car to a full stop before the collision occurred. The eastbound motorman, who was killed, appears to have made no effort to stop his car and is said to have ignored orders to wait for the westbound car at Wilson, some distance west of Dune Park. The eastbound car was much more broken up by the collision than the other and all of the passengers killed were in its crowded smoking compartment at the forward end of the car. No one on the westbound car was seriously injured.

A construction train operated on the Grand Trunk Pacific Ry. by the Corbett-Floesch Co. was wrecked June 18 near Corbettville, New Brunswick. The train became unmanageable on a down grade and the three rear cars left the track on a curve. There were about 25 workmen on the train and, of these, two were killed and two others injured.

The locomotive of a train on the Great Northern Ry. was derailed on the New Westminster (B. C.) side of the Fraser River bridge June 19 and, breaking loose from its train, plunged into the river and was entirely submerged. The engineer and fireman were killed. The accident is ascribed to a misplaced switch.

A passenger train on the Chicago & Northwestern Ry. ran into a wreck in the yards near North Fond du Lac, Wis., June 17 and was derailed. The engineer was killed, and the fireman and two passengers were seriously injured.

The Oriental limited westbound on the Great Northern Ry. was derailed June 21 by a landslide near Ural, Mont. Thirty passengers were injured.

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A TRAIN WENT THROUGH THE TRESTLE which carries the Oregon & Southeastern R. R. across the Roe River at a point about five miles east of Cottage Grove, Ore., June 5, and was partially submerged in the river below. The engineer was killed and 15 persons were injured. The train consisted of only one car besides the engine and tender. The trestle gave way behind the locomotive and the brakes were applied in time to prevent it from rolling back upon the wrecked car.

A RESERVOIR WALL GAVE WAY June 21 at the water-works pumping station six miles north of St. Joseph, Mo., and three men were killed by the escaping water. The accident is ascribed to high water in the Missouri River.

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A POWDER MILL EXPLOSION at Pompton Lakes, N. J., June 21, resulted in the death of two men. The explosion occurred in the priming house of the Du Pont powder works.

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A BOILER EXPLOSION in the plant of the Denver Gas & Electric Co., at Denver, Colo., June 15, wrecked a generator and the roof and walls of the boiler room. Four men were killed and as many more were injured.

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HEAVY RAINS IN VIRGINIA June 12-13 washed out several miles of railway track in Wise Co. and caused the Powell River to rise 10 ft. in two hours. The Powell Valley Light & Power Co.'s plant, which furnishes light for many of the towns in Wise Co., was disabled by the flood.

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ANOTHER KILLED BETWEEN PASSING STREET cars in Chicago has brought to a focus the agitation against insufficient clearance between car tracks. The victim tried to dodge a southbound car on State St., a busy thoroughfare, and was caught between it and a northbound car. He was rolled between the sides of the two cars and crushed to death. The local reports give this as the 24th killing of the kind since wide cars were put on the closely spaced tracks.

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A TUNNEL CAVED on the Atchison, Topeka & Santa Fe Ry. at Glen Frazer, Contra Costa county, Cal., on June 12, blocking all traffic on that section of line. The tunnel is something over a mile in length. The cave-in is charged to the slow action of water. The same tunnel was blocked in 1906, after the great earthquake, and was opened again only after several months' work. No train was caught in the present fall, and as the Southern Pacific crosses the Atchison at points only a few miles east and west of the tunnel, trains are sent around with but little local inconvenience.

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THE "MAURETANIA," giant Cunard steamship and persistent breaker of transatlantic records, in the trip ending June 21 clipped 50 minutes off her previous eastbound record of 4 days, 18 hrs., 11 min., made on May 10. The average speed was therefore 25.88 knots (29.8 land miles) against 25.70 knots (29.6 miles) the best previous average speed. The practical value of this reduction in time lay in the ability to land passengers leaving New York on Wednesday, at Liverpool on Monday—a feat never before accomplished. A special train conveyed the passengers to London, making the time between New York and London about 5 days 8 hrs.

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THE NEW YORK, NEW HAVEN & HARTFORD R. R. has announced its intention of extending its single-phase, high-speed, electric-train service from Stamford to New Haven, Conn. The original line out of New York City, between Woodlawn, N. Y. and Stamford, Conn., was described in Engineering News, Sept. 5, 1907. The results of operation were discussed in the issue of Dec. 31, 1908. The line construction on this extension will cover four tracks, but these tracks will probably not be used immediately for regular commercial electric service and only preliminary operation will prevail for both freight and passenger service. At the present time no freight is hauled by electric locomotives between Stamford and Woodlawn, but will be after the installation of electric-train service on the Harlem River branch. Instead of operating multiples of the present locomotives, it is expected that a lower-speed type of high tractive effort will be developed.

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ANOTHER SECTION OF THE PANAMA CANAL has been completed. It is located near Matachin, just below Gamboa, where the Chagres River intersects the canal route. At this point the river makes a deep bend, and it was necessary to cut through this bend to provide a channel for the canal. The cutting is about half a mile long, 500 ft. in width and has an average depth of about 45 ft. The last dipper full of earth was removed from the cut on Tuesday, May 25. As soon as the tracks are removed from the section, the Chagres River will be turned and allowed to flow through it, and the present bed of the Chagres will be used as a dumping ground.

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A NEW SUBWAY IN NEW YORK CITY is in prospect, the result of the recent Legislature's passing a law removing some of the restrictions placed on privately owned subways by a law passed three years ago. An offer has been made by a new corporation for an extensive north-south subway, from Jerome Ave. in Bronx borough via Lexington Ave., Irving Place and Broadway in Manhattan borough, and via the Manhattan Bridge (now being built) over the East River to Brooklyn borough, whence it extends along Flatbush Ave. extension, Fulton St., Lafayette Ave. and Broadway to a connection with the Williamsburgh Bridge to return to Manhattan borough. The company offers a 5-cent. fare with transfers at its own intersections. The city is to be permitted to take over the whole line after ten years or after amortization of the debt, for actual cost plus 15%. The proposal has been received with favor by the Public Service Commission and the Board of Estimate and Apportionment.

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COMPETITIVE DESIGNS FOR PARK BRIDGES are required by the Board of Park Commissioners of Minneapolis, Minn. Six bridges are to be built, and three prizes, totaling $1,500, are offered for the best designs, to be submitted by Sept. 1. The bridges are to be of stone, concrete, or a combination of both. Fuller details may be had by addressing the Board of Park Commissioners of Minneapolis.

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RAISING THE ALLEGHENY RIVER BRIDGES at Pittsburg, Pa., is again being agitated, after several previous Secretaries of War declined to take affirmative action in the matter. It appears that the several bridges between Pittsburg and Allegheny have different clearances above water, and most of them are too low for the full development of navigation, now that the regulation of the Allegheny River has reached an advanced stage. Most of these bridges are owned by private corporations, and the situation is complicated by proposals that the city buy the bridges.

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ELECTRICAL ENGINEER GRADUATES of the Massachusetts Institute of Technology in the past year were 40% graduates of other colleges with degrees of B. A., Ph.B. and B. S. largely.

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A NATIONAL CONSERVATION CONGRESS is to be held at Seattle, Wash., Aug. 26 to 28, under the auspices of the Conservation Association of the State of Washington. Sessions will be held in the Auditorium of the Alaska-Yukon-Pacific Exposition.

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A GREAT HARBOR FOR LOS ANGELES has been under consideration for some time, and a working scheme has been at least tentatively agreed to by various local interests. The plan involves the consolidation of San Pedro and Wilmington with Los Angeles, thus bringing the San Pedro and Wilmington harbor within the city limits of the enlarged Los Angeles, although it will be distant many miles from what is now the main part of that city. Three consolidation committees, one for each city, have agreed on a general plan for consolidation and for harbor development, and various mercantile and civic organizations have approved the plan, including the Merchants' & Manufacturers' Association and the Municipal League of Los Angeles. Necessary petitions for a special election to vote on consolidation have been circulated, signed by the required number of voters and filed. It is expected that a call for such an election will be held at an early date.

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## Personals.

Mr. Walter E. Winn has been appointed City Engineer of Danville, Ill.

Mr. Guy C. Dunn, District Engineer of the Grand Trunk Pacific Ry., formerly at St. John, N. B., has been transferred to Winnipeg, Man.

Mr. C. H. Temple, formerly Master Mechanic of the central division of the Canadian Pacific Ry., has been appointed Assistant Superintendent of Motive Power with headquarters at Winnipeg, Man.

Mr. Chas. R. Bettes, M. Am. Soc. C. E., and Mr. John T. Fetherston, Assoc. M. Am. Soc. C. E., have entered into association with the firm of Tribus & Massa, consulting engineers, 86 Warren St., New York City.

Mr. John E. Ericson, M. Am. Soc. C. E., City Engineer of Chicago, Ill., has been knighted with the order of Vasa by King Gustaf V. of Sweden. Mr. Ericson was born in Sweden, but has resided in Chicago for 28 years and has been City Engineer for the past twelve years.

Mr. E. Tappan Tannatt, formerly Professor of Civil Engineering at the Montana State College of Agriculture and Mechanic Arts, has opened an office as a consulting engineer at 516 Empire State Bldg., Spokane, Wash.

Mr. C. W. Lawrence, Assoc. M. Am. Soc. C. E., Professor of Civil Engineering at the James Millikin University, Decatur, Ill., has been appointed Professor of Civil Engineering in the University of Southern California, Los Angeles, Cal. He will take up the duties of his new position early in September.

Mr. Robert Thompson, a civil engineer of Elmhurst, Long Island, was struck in the breast by a bullet, June 22, while working for the Citizens' Water Supply Co. at Train's Meadow. The man who fired the shot could not be seen, and a searching party failed to discover him. Mr. Thompson was taken to a hospital in Long

Island City, where it was found that his wound, although serious, would not prove fatal.

Mr. Charles H. Fitch, M. Am. Soc. C. E., has relinquished his position as Engineer and Executive Officer of the U. S. Reclamation Service to become Manager of the Idaho Irrigation Co., Limited, with offices at Richfield, Idaho. Mr. D. W. Murphy, formerly Project Engineer in charge of the Klamath Project in Oregon and California, has been transferred to the Washington office in charge of engineering and will also assume certain duties formerly discharged by Mr. Fitch.

Mr. Harold Pender, Assoc. Am. Inst. E. E., has been appointed Professor of Theoretical and Applied Electricity at the Massachusetts Institute of Technology. Prof. Pender is a graduate of Johns Hopkins University and took the degree of Ph.D. at that university in 1901 under Prof. Rowland. He taught for a year and a half, during which period he completed the classical experiments of Prof. Rowland which demonstrated the magnetic effect of a moving charge of electricity. Poincaré, Professor of the Sorbonne in Paris and a member of the French Academy, suggested the desirability of having these experiments performed in Paris for the benefit of French Scientists, and the Carnegie Institution, of Washington, arranged with Prof. Pender to go to France for that purpose. Upon returning from France, he went into the employ of the Westinghouse Electric & Manufacturing Co. and has since been in engineering practice. His courses at the Massachusetts Institute will consist of one for third-year undergraduates and of others for graduates in the advanced theory of the flow of currents and transmission of power. He will be in charge of the experimental research of advanced students.

## Obituary.

W. W. Dudley, Past-President of the National Fire Protection Association, died June 9 at Chicago, Ill.

Caleb J. Camp, at one time President of the Hartford & Connecticut Western Ry. (now the Central New England Ry), died June 19 at his home in Winsted, Conn., aged 95 years.

Frank M. Campbell, Manager of the Philadelphia branch of the Jones & Laughlin Steel Co., shot himself with a revolver June 21 at the Marsh Hotel in Van Wert, Ohio, and died almost immediately. He had been suffering for some time from nervous breakdown.

William F. Fox, State Superintendent of Forests of New York, died June 16 at his home in Albany, N. Y. Mr. Fox was born at Ballston Spa, N. Y., in 1840 and was graduated at Union College in 1860. He served in the Civil War as Captain, Major and Lieutenant-Colonel of the 107th New York Volunteers. Since 1885 he has been connected with the New York State Forestry Department, and he was the author of a number of books on forestry.

Henry F. Baldwin, M. Am. Soc. C. E., Chief Engineer of the Oregon & Washington R. R., died recently at his home in Seattle, Wash. Mr. Baldwin was born at Waterbury, Md., in 1862 and was a graduate of the Massachusetts Institute of Technology in the class of 1884. Soon after graduating, he entered the service of the Louisville & Nashville R. R. as a rodman, and he remained with that road until 1889 at which time he had been advanced to the position of roadmaster. From 1889 to '90 he was a division roadmaster for the New York, Lake Erie & Western R. R. and, in the latter year, he became Chief Engineer of the Chicago & Eastern Illinois R. R. He relinquished this position in May, 1894, when he became Chief Engineer of the Chicago, Peoria & St. Louis Ry. He was subsequently Engineer of Maintenance of Way of the Erie R. R. at Jersey City, N. J., from 1895 to 1900, and Chief Engineer of the Chicago & Alton Ry., from 1900 to 1904. In January, 1904, he gave up railway work to become Vice-President and General Manager of the Du Pont Powder Co., whose president, T. Coleman Du Pont, had been a classmate of his at the Massachusetts Institute of Technology. He resigned the vice-presidency of the Du Pont Co. in 1907 to return to railway work.

## Engineering Societies.

COMING MEETINGS.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-26. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 24-26. Annual convention in New York and Brooklyn. Secy., Arthur L. Williston, Pratt Institute, Brooklyn, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
June 24-26. Summer convention at Detroit, Mich. Secy., Wm. J. Baxter, 29 W. 39th St., New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
July 5-9. Annual meeting at Seattle, Wash. Secy., A. H. Dimock, City Hall, Seattle, Wash.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
July 6-9. Annual convention at Bretton Woods, N. H. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 13-15. Annual convention at Toledo, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 15-16. Summer meeting at Indianapolis, Ind. Secy., W. M. Mackay, P. O. Box 1818, New York City.

NATIONAL IRRIGATION CONGRESS.
Aug. 9-14. Annual meeting at Spokane, Wash. Secy., B. A. Fowler, Phoenix, Ariz.

TRAVELING ENGINEERS' ASSOCIATION.
Sept. 7-10. Annual convention at Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

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ENGINEERS CLUB OF CINCINNATI.—At the meeting on June 17, held at the rooms of the Literary Club, a lecture on "Sewage Purification," illustrated by lantern slides, was delivered by Mr. A. Elliott Kimberley, of Columbus, Ohio., Special Assistant Engineer of the Ohio State Board of Health.

STREET RAILWAY ASSOCIATION OF THE STATE OF NEW YORK.—The 27th annual convention will be held at Lake George, N. Y., June 29-30. Papers will be presented on "Electric Railway Accounting," "Schools for Trainmen" and "Latest Developments in Electric Railway Apparatus." The secretary is Mr. J. H. Pardee, 611 West 137th St., New York City.

BOSTON SOCIETY OF CIVIL ENGINEERS.—The June excursion which took place on June 16 included an inspection of the newly constructed Forest Hills terminal of the Boston Elevated Ry. The members were carried by a special train of four cars from the Union-Friend station of the Washington St. tunnel to the elevated terminal at Forest Hills. This was the first passenger train to travel over the new elevated structure, which is expected to be put into regular service in October.

NEW YORK ELECTRICAL SOCIETY.—At the annual meeting held in New York City on June 15, officers for the ensuing year were elected, as follows: President, Theodore Beran; Vice-Presidents, John Bottomley, Frederick A. Scheffler and Chas. H. Hadlock; Treasurer, Henry A. Sinclair; Secretary, George H. Guy. After the election, Mr. Cloyd Marshall gave an informal address on "The Commercial Development of Wireless Telegraphy" and at the conclusion of Mr. Marshall's address the members of the society made an inspection of the wireless station of the United Wireless Telegraph Co. on the roof of the Waldorf-Astoria hotel, in which the meeting was held.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.—The program for the fifth congress, to be held at Copenhagen, Denmark, Sept. 7-11, will include the reading of papers entitled "Development of the Cement Industry in Denmark," by Poul Larsen, and "On the Practical Use of the Microscope in Testing Metals and Alloys," by J. E. Stead.

The papers listed below will be presented for discussion and will be published in German, French and English. Copies of these papers are free to all members of the association. Any member of the American Society for Testing Materials may become a member of the international association upon payment of $1.50 to the secretary of the American society. The papers to be presented are as follows:

METALS.

1. Metallography. Official report by E. Heyn, Gr.-Lichterfelde; "Special Steels," by L. Guillet, Paris; "Heat Treatment of Spring Steel," by Lawford H. Fry, Paris.

2. Tests for Hardness. Official report by F. Ludwik, Vienna; "Simplified Apparatus for Ball Pressure Tests," by E. Heyn and A. Martens, Gr.-Lichterfelde; "The Cone Pressure Test," by A. Gessner, Vienna; "The Brinell Method of Hardness Determination," by H. Moore, London.

3. Impact Tests. Official report by G. Charpy, Paris; "Definition of Resilience in Connection with Impact Tests," by L. Revillon, Paris; "Impact Tests on Notched Bars at Different Temperatures," and "Application of Modern Testing Methods to Alloys of Copper," by L. Guillet and L. Revillon, Paris; "Impact Tensile Tests," by P. Brevil, Paris; "Impact Bending Tests on Notched Bars," by F. Schüle and E. Brunner, Zurich; "Comparative Statical and Dynamical Notched-Bar Tests," by A. Leon and P. Ludwik, Vienna; "The Dynamic Load and Impact Tests," by Welikhoff, Moscow; "Piece Tests of Important Structural Parts," by O. Hönigsberg, Vienna.

4. Testing Metals by Alternating Stresses. Official report by J. E. Howard, Watertown; "Quality and Time Tests of Copper Wire," by F. Schüle and E. Brunner, Zurich.

5. Testing of Cast Iron. Official report by R. Maldenke, New York; "The Testing of Cast Iron," by Sulzer Bros., Winterthur.

6. Influence of Increased Temperature on the Mechanical Qualities of Metals. Official report by M. Rudeloff, Gr.-Lichterfelde W.

7. Miscellaneous. "A New Mirror-[illegible]aratus for the Measurement of Elasticity," by B. Kirsch, Vienna. Reports on Problem 28; "Magnetic and [illegible]ric Properties of Materials in Connection with Their [illegible]chanical Testing": Reports by A. Grünhut and Dr. Wahn, Vienna; Prof. P. Weiss, Zurich; Ew. Rasch, G[illegible]ichterfelde; J. W. Esterline, Lafayette. Report on Problem 24; "Nomenclature of Iron and Steel with a D[illegible]tion of Their Microscopic Constituents," by M. H. Howe, New York, and A. Sauveur, Boston. Report on Problem 1; "International Specifications for Testing and Inspecting Iron and Steel," by A. Rieppel, N[illegible]berg. Report on Problem 38; "Principles for Specifications of Copper," by L. Guillet, Paris. "Conclusions Drawn from Studies of the Qualities of Rails, as Basis for Conditions of Tender for Rails," by N. Beleiubsky, St. Petersburg; "Unification of Methods for Testing Steam, Gas and Water Pipes," by A. C. Karsten or H. [illegible] Hannover, Copenhagen; "The Spark Method for Grading Steels," by M. Bermann, Budapest; "Internal Friction in Loaded Materials," by G. H. Gulliver, Edinburgh. "Relating to the Principles of Technological Mechanics," by P. Ludwik, Vienna; "Tenacity and Ductility," and "The Connection Between the Permanent Sets Produced by Tensile and Compressive Strains," by Misangyi, Budapest; "General Korobkoff's Definition of Tenacity," by N. Beleiubsky, St. Petersburg.

CEMENT, STONES, CONCRETE.

1. Reinforced Concrete. Official report by F. Schüle, Zurich; "Experimental Researches on the Subject of Building Constructions," by Ch. Rabut, Versailles; "Accidents in Connection with Reinforced Concrete Structures," by F. v. Emperger, Vienna; "Disturbances in the Bond Between Different Materials," by Dr. A. Leon, Vienna; "Contribution to Methods of Investigation Into the Elastic Longitudinal Deformation of Concrete," by B. v. Breszlowsky, Budapest; "Influence of Repeated Strains on the Bond Between Concrete and Iron with Clean and with Corroded Surface," by B. Kirsch, Vienna; "Influence of Thin Transverse Connections on the Strength of Concrete," by W. Nekrassow, St. Petersburg.

2. Progress in Methods of Testing. Official report by R. Feret, Boulogne-sur-mer; Reports on Problem 9; "Rapid Tests for Determining the Strength of Hydraulic Cements," by F. Berger, Vienna; E. Deval, Paris; A. Greil, Vienna. Report on Problem 30; "Simplest Method for the Separation of the Finest Particles in Portland Cement by Liquid and Air Process," by M. Gary, Gr.-Lichterfelde. Report on the Work Done by Commission 11; "Testing Puzzolanes with the Object of Determining Their Value for Mortars," by G. Herfeldt, Andernach. Report on Problem 40; "Unification of Specifications for Gypsum," by M. Gary, Gr.-Lichterfelde, and R. Feret, Boulogne-sur-mer.

3. Tests by Means of Prisms and Standard Sand. Official report by F. Schüle, Zurich.

4. Constancy of Volume. Official report by B. Blount, London.

5. Cement in Sea Water. Official report by W. Czarnomsky and A. Baykoff, St. Petersburg; "Experiments on the Decomposition of Mortars in Sulphurated Water," by J. Bied, du Teil; "Experiments with Reinforced Concrete in Sea Water," by M. Möller, Braunschweig; "Cement in Sea Water," by A. Poulsen, Copenhagen.

6. Weathering Resistance of Building Stones. Official report by A. Hanisch, Vienna; "Relating to the Theory of the Influence of Frost on Natural Stones," by Dr. H. Seipp; "Model for Testing Stones," by Dr. J. Hirschwald, Charlottenburg; "Resistance to Frost," by E. Leduc, Paris.

7. Miscellaneous. "The Binding of Mortar After Several Interruptions in the Work," by B. Kirsch, Vienna; "The Strength, Elasticity, Water-Permeability and Setting Qualities of Trass, Trass-Cement and Cement-Lime Mortars," by H. Renezeder, Vienna; "The Specific Heat of Refractory Materials at High Temperatures," by J. W. Mellor, Stoke-on-Trent.

SUNDRIES.

1. Oils. Official report by M. Albrecht, Hamburg.

2. Caoutchouc. Official report by E. Camerman, Brussels; "Mechanical Testing of Caoutchouc," by P. Breuil, Paris.

3. Wood. Official report by W. K. Hatt, Lafayette.

4. Paints on Metallic Structures. Official report by S. S. Vorhees, Washington; "Attacks on Iron by Water and Aqueous Solutions," by E. Heyn, Gr.-Lichterfelde; "Paints on Metallic Structures," by E. Camerman, Brussels; "A Plea for International Investigation Concerning Protective Coatings for Iron and Steel," by J. Cruickshank Smith, London.

5. Miscellaneous. "The International Technical Regulation of Testing," and "Testing in the Domain of Automobile Work," by W. Exner, Vienna.

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